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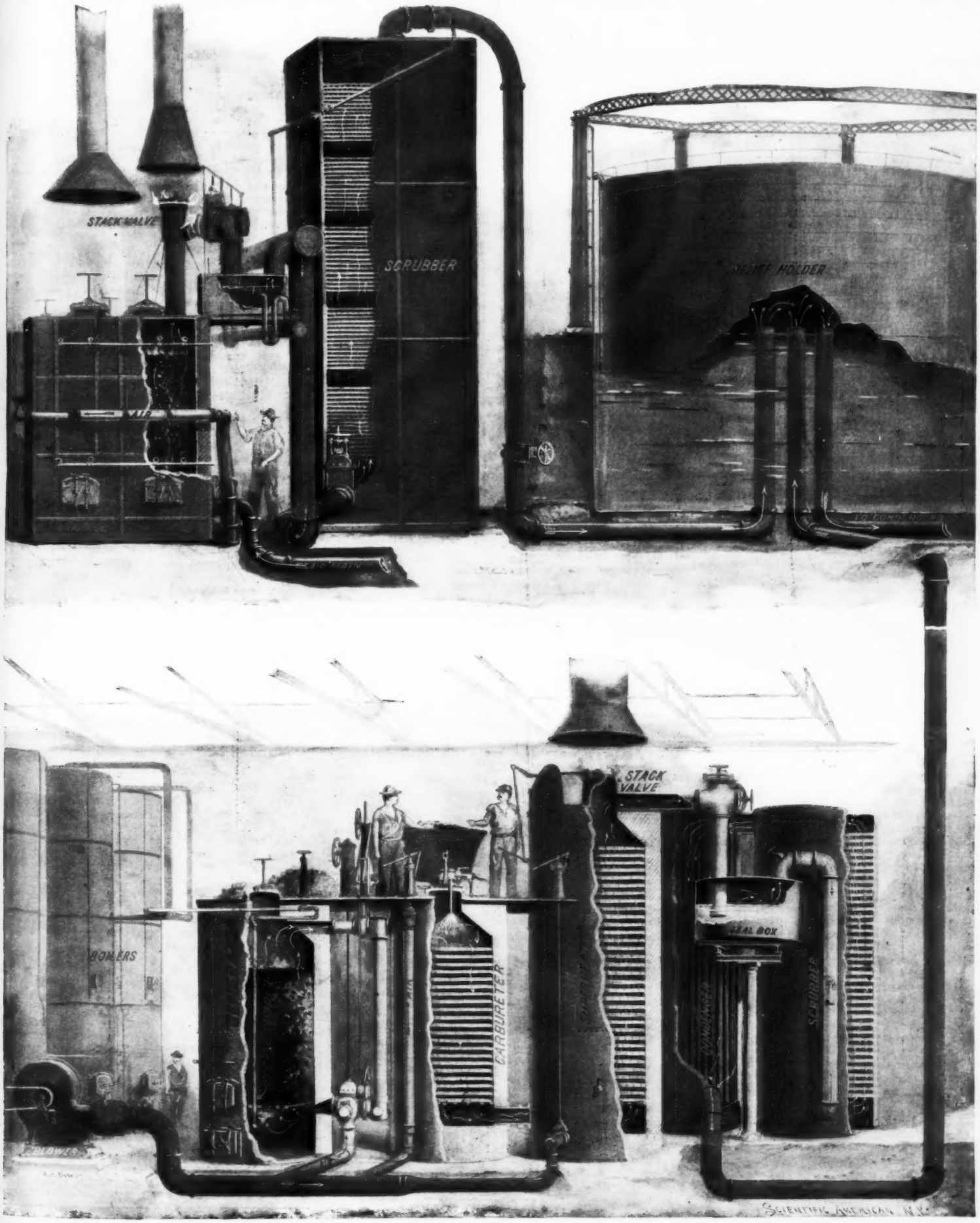

THE MANUFACTURE OF WATER-GAS.

MANUFACTURE OF WATER-GAS AT THE FORTY-FOURTH STREET STATION, NEW YORK.—II.

THE manufacture of coal gas was illustrated and described in our issue of October 6, 1900, the plant of the Consolidated Gas Company at Fourteenth Street being selected for illustration. The present article is devoted to a description of the manufacture of water-gas, as carried on by the same company in their plant at the foot of West Forty-fourth Street, in this city. Water-gas is a gaseous mixture which consists mainly of carbon monoxide and hydrogen. It is produced by forcing steam through a body of incandescent fuel. Although water-gas possesses great heating power, it is practically useless as an illuminant, and hence when it is manufactured, as in the present instance for lighting purposes, it has to be mixed with a certain proportion of illuminating gas before it is delivered to the city mains. Of our two front page engravings representing the Forty-fourth Street plant, the upper one shows the details of the plant for making pure water-gas, while the lower cut shows a complete plant for making illuminating water-gas; the last-named being known as the Lowe apparatus.

ILLUMINATING WATER GAS.—A single element of the Lowe apparatus, as shown in our illustration, consists of a generator, a carbureter, a superheater, a condenser, and a scrubber, with the necessary boilers and blowers to supply, under pressure, the necessary steam and the air. The generator is a vertical shell 8 feet 6 inches in diameter and 16 feet high. It is lined with firebrick, and at about a fourth of its height is a grate on which the fuel (coal and coke) is loaded to a depth of 7 feet. The carbureter is of the same dimensions as the generator and is also lined with firebrick, while the interior is filled with firebrick checkerwork. The superheater is 8 feet 6 inches in diameter by 20 feet in height, and like the carbureter it is lined with firebrick and filled with checkerwork. The generator and carbureter are provided with manholes at the top, while the superheater terminates in a stack valve as shown. Each of the three cylinders is provided with air inlets, with connection to a series of air mains, that are fed by a centrifugal blower. A series of pipes connecting the cylinders with one another facilitates the flow and control of the gases during the process. One air connection leads beneath the grate of the generator, another leads to the top of the carbureter above the checkerwork, and a third connection admits air below the checkerwork of the superheater. There is also a steam pipe which terminates in a jet below the grate of the generator; and by means of a pipe connecting with the oil supply, a spray of oil can be injected upon the top of the checkerwork in the carbureter.

In operation a supply of coal and coke fuel is loaded into the generator from a platform at the level of the top manhole, until it stands about 7 feet deep upon the grate. The stack valve of the superheater is opened, and the steam and oil supply are closed. Air is then blown through the fuel in the generator, the resulting products of combustion passing through the checkerwork in the carbureter and superheater, and finally escaping through the open stack valve in the last-named element. The air, in blowing up through the fuel, combines with the carbon of the fuel to form carbon monoxide, which is conveyed from the top of the fuel through piping to the top of the carbureter. Here it meets a fresh supply of air from the air mains, and taking up more oxygen, forms carbonic acid gas. This combustion takes place as the gases pass down through the checkerwork. From the bottom of the carbureter the gases are led to the bottom of the superheater where, if it is necessary, a fresh supply of air is added to produce complete combustion. The gases then travel up through the checkerwork in the superheater, and finally escape through the stack valve. By the proper regulation of the air supply the combustion is rendered so complete that the gases as they pass to the stack are completely colorless. During the blow, which lasts about four minutes, the checkerwork in the carbureter and superheater is raised to a cherry red heat.

The various air valves and the stack valve are now closed, and steam is turned on below the grate of the generator. In passing up through the incandescent fuel the steam is decomposed into hydrogen and carbon monoxide. The oxygen in the steam combining with the carbon in the fuel forms carbon monoxide, and sets free the hydrogen, the gases as they pass from the top of the generator consisting chiefly of carbon monoxide and hydrogen, with a small amount (about 3½ per cent) of carbon dioxide, whose presence is due to the fact that a small amount of steam has not been thoroughly decomposed. This water-gas now passes to the top of the carbureter, where it is mixed with a spray of oil (naphtha or gas oil) which is forced in under a pressure of 70 pounds to the square inch. The mixture of water, gas and sprayed oil now travels through the checkerwork of the carbureter and the superheater, the heat of which transforms the mixture into a fixed gas whose average analysis, as shown by tests which are taken regularly at the works, is as follows:

Carbon dioxide	3.4
Illuminants	12.3
Oxygen	.5
Carbon monoxide	29.1
Hydrogen	30.3
Marsh-gas	21.3
Nitrogen	3.1

From the top of the superheater, the fixed gas now passes through the water of the seal-box, the object of the seal being to prevent any possible reversal of the flow of gas. From the sealed box the gas is led to the bottom of the scrubber, a vertical cylinder which is filled with a large number of superimposed wooden slats or gratings. A spray of water plays continually upon the top grating and trickles down through and over those beneath, thereby providing an exceedingly large wetted surface. As it passes up through the innumerable openings of the gratings the gas is cooled, and the heavy oils and pitch which it contains are condensed and deposited. The gas then passes between the tubes of a vertical condenser, consisting of a shell, containing a number of tubes through which cold water is constantly circulating, where it is cooled to the temperature of the atmosphere, the lowering of its temperature causing the condensation of any oils and pitch that may be left in the gas. The purified gas is now led to a relief holder, as shown in the illustrations.

The operation of blowing the air is known as the "blow," and that of blowing the steam as the "run." The run lasts about six minutes, at the end of which time the fuel and the checkerwork have been so far cooled that it is necessary to heat them again. To this end the steam and oil supply are shut off, the stack valve is opened, and the air blast is again turned on, as already described. The flow of steam, however, at the succeeding "run" is reversed by means of a reversing valve on the steam connections, the steam now being introduced at the top of the fuel and passing down through the same. The object of reversing is to keep the fuel at a more even temperature, for if the "run" were all in one direction, say upwardly, the lower part of the bed of fuel would be comparatively cool and the top of the fuel excessively hot.

In the Lowe apparatus, as thus described, it is possible to vary the illuminating power of the gas by varying the amount of oil that is sprayed into the carbureter. The gas made at the Forty-fourth Street plant is of about twenty-eight candle power, and the capacity of the Lowe plant is 2,000,000 cubic feet per twenty-four hours.

STRAIGHT WATER-GAS PLANT.—In addition to the Lowe apparatus as above described, there is at the Forty-fourth Street station a complete plant for manufacturing non-illuminating water-gas. The product is conveyed direct to the relief holder, where it is mixed with the product of the Lowe apparatus, preparatory to being mixed with an oil gas that is prepared in a plant which will form the subject of an article in a later issue. The straight water-gas plant is a French system, which was introduced into this country in 1877, and was the first water-gas plant of any kind to be erected in this country. It consists of a generator, which is technically known as the "gasogene," and a scrubber, as shown in the upper illustration on our front page. The gasogene consists of a rectangular shell, built up of wrought iron plates, which measures 6 feet by 12 feet by 14 feet high, and is lined throughout with firebrick. Two feet from the bottom is a grate for the coke and coal fuel, which is introduced through a charging door at the top of the furnace. Air is fed to the gasogene at two different levels, one set of pipes leading in below the grate, another at about the mid-height of the generator. There is also a steam connection at the bottom and one at the top. In the operation of blowing or heating up, the air supply at the bottom and at the center of the fuel is opened, the stack valve being left open, and the blow is continued for about five minutes, at the end of which time the fuel is heated to the proper temperature. The stack valve is then closed, the air supply shut off, and steam is turned on under the fuel bed, when the same reactions take place as were described in connection with the generator of the Lowe apparatus. The gases pass off from the top of the gasogene, through a seal-box, and down to the bottom of the scrubber, a large rectangular structure filled with a series of trays, at the top of which a spray of water is continually playing. As the gas passes up through the scrubber it is cooled and washed, the water serving to catch any dust or dirt which may have been carried over from the gasogene. The gas is here cooled down from about 180 deg. F. to 60 deg. F. From the top of the scrubber it is led to the relief holder, where it is mixed with the illuminating water-gas from the Lowe apparatus. The run lasts for about twenty minutes. After the steam has been blown up through the fuel for ten minutes, the valves are reversed and the steam is blown downward through the fuel for the next ten minutes, the object of the reversal being, as in the case of the Lowe apparatus, to maintain the fuel at an even temperature throughout its whole mass. The capacity of the gasogene plant is 8,000,000 cubic feet per twenty-four hours.

It will be seen that there is a radical point of difference between the gasogene and the Lowe apparatus, in the fact that, while the latter manufactures a finished illuminating gas, the former manufactures a simple water-gas without any illuminating qualities. The products of both plants are carried, as we have seen, to a common relief holder. From the relief holder the mixed gases are led to the condensers of an oil-gas plant, where they are mixed with the oil-gas, and the combined mixture is condensed, scrubbed, purified, and measured, and finally carried to a main holder of 2,000,000 cubic feet capacity, from which it is led to the city mains. This oil-gas plant will form the subject of an illustrated article in a later issue.

A number of manganese mines in Poland have just been ceded by their owners, who are capitalists of Warsaw, to an English syndicate.

[Continued from SUPPLEMENT No. 1626, page 26047.]

THE TECHNOLOGY AND USES OF PEAT.*

By C. W. PARMELEE.

MANUFACTURING PEAT FUEL.

DIGGING.—The first operation on most bogs is draining the area to be worked. It is not advisable to drain the whole bog even if feasible, for the peat will dry and become brittle or freeze in the winter, rendering it in either case difficult if not impossible to work. Further, complete draining will kill the peat-forming vegetation. After the portion selected for working is sufficiently well drained, the surface growth is removed and, as will be shown later, this may be of some value. After this has been accomplished the digging may begin, and we will describe the method usually followed where labor is cheap.

A trench is dug with vertical sides of sufficient width to permit a laborer to work freely in it. The cutting of the sods then proceeds either from the surface downward or in a horizontal direction, depending upon the presence or absence of strata. In the former case, the laborer standing above, thrusts his spade, sometimes called a stane, into the peat a few inches back from the face and parallel to it. The laborer in the trench cuts this sod loose by a thrust of his spade and transfers it to a board from which it is lifted by a fork to a wheelbarrow and thus to the drying ground. The spade used by the laborer standing on the surface of the bog is a heavy tool with sharp edges and one edge turned at right angles to the blade and sometimes a sharp fin at the middle of the blade and at right angles to it. Such devices enable the user to cut one or more surfaces of a sod with a single thrust.

Cutting peat by machinery has been practised for a great many years in Germany. The apparatus in use is known by the name of its inventor Browsowsky, who first brought it forward in 1842. The cutting device is like the three sides of a box in arrangement and each of the lower edges is sharpened for cutting. This cutter is forced down into the peat following the vertical face of the diggings. When sunken to a sufficient depth which may be as far as twenty feet, a blade attached to the cutter is made to cut under, severing the prism of peat which may be raised. The apparatus can only be used along the face of trenches already dug. Such a machine operated by two men can cut 3,000 cubic feet in 10 hours. The prism so cut is about 1½ by 2 feet in cross section and from 10 to 20 feet long. This is then cut into convenient sized pieces.

Peat sods are dried by exposure to the air which of course renders the industry wholly dependent upon favorable weather conditions. Consequently the digging of peat can be carried on only during the late spring, summer and early autumn. It cannot be continued very late in the autumn, for the cut peat must have time to dry before frost, otherwise great loss will be occasioned by the freezing. In order to facilitate drying, the sods are generally loosely piled on a flat, dry piece of ground. Sometimes they are piled on elevated racks, which may be protected by a roof, or the drying ground may be thickly set with poles furnished with spikes projecting outward, upon which the sods are transfixed. The advantage of such methods lies in the fact that drying always proceeds more rapidly above the surface of the ground. If the peat is deficient in fiber, or crumbly on drying, or to be had only in a pulpy condition, the above described process is wholly unsuitable, and recourse must be had to other methods which will give a more solid product. This result is readily attained by kneading and mixing. A number of different methods are in use abroad which we will briefly describe.

Trodden Peat.—The peat is dug in irregular lumps and thrown into a vat or pit, and water is added if too dry. The mass is trodden by barefooted men or women, or by horses or oxen, until it is reduced to a paste. This paste may be filled into molds and, when sufficiently solid, emptied on the drying floor. Or the pulp may be run into a many-celled frame. It is compressed by pounding, and when sufficiently firm is emptied out. Or the pulpy mass is spread out on a smooth surface, allowed to dry somewhat and then compacted by rolling, beating or treading by men or women wearing boards on their feet. It is then cut with a long knife into bricks and removed to the drying floor. This method is very general in Holland. If it is impracticable to drain the bog, and the peat can be removed in a pulpy condition, it is frequently dredged out of the trenches by laborers using nets of close mesh or bagging.

All these methods are unsuited for use in this country owing to the high cost of labor. Besides, the product has many faults. It is loose, brittle, and bulky, and consequently it does not bear transportation well. The burning of it in industrial establishments requires much labor and attention, and the use of very large fire mouths and grates. The space for drying and storing must be considerable owing to the bulk. The season for cutting and drying is very limited and the chance of loss because of unfavorable weather is great. To avoid these difficulties and to secure a useful fuel has been the goal of many inventors, and a great variety of mechanical devices has been tried both in this country and abroad with varying success.

The most successful systems are those which are designed to secure a combination of crushing and tearing of the fiber and a thorough mixing of the mass. This not only insures a destruction of all roots and

* Abstracted from the Annual Report of the State Geologist of New Jersey.

fiber but, according to a theory, breaks down certain compounds called protozane. These particles have a nature similar to starch or glucose and when ruptured act as a binder.

The various methods which have been employed for the purpose of condensing peat are too numerous to discuss in detail. The following methods are in successful operation. They are given as typical processes.

Pulped Peat.—This method is similar to one already described as "trodden peat" with this difference, that the peat is prepared by machinery. It is very successfully used at Sparkjer in Denmark, and very generally in Holland. This operation as conducted in the latter country requires the use of a scow, upon which is placed the necessary machinery, consisting of a dredge, a kneading and mixing machine and a pump. The kneading and mixing machine is essentially a metal trough through which passes one or more shafts bearing knife-like blades. These shafts revolve and disintegrate the material raised by the dredge. The pulpy mass is delivered by the pump upon cleared ground, on the moor or on nearby land, where it dries until firm and is then cut into bricks, which are removed for more complete drying. The scow floats in one foot of water. The stripping or accumulation on top of the peat is used as filling or for building dikes. A similar method was used in Canada in 1864 which produced dried peat at 92c. per ton, it is said, but operations were subsequently discontinued.

Compressed Peat.—Attempts which have been made to drive out the water mechanically held in peat by subjecting the raw peat to pressure have resulted in failure. At a Canadian plant, operated from 1900 to 1902, the moss was subjected to a pressure of two tons per square inch. An average sample of the raw material contained 77.71 per cent water. On leaving the press it contained 63.48 per cent, whereas drying under ordinary atmospheric conditions will remove 30 to 40 per cent moisture. If the peat is first broken and dried better results may be had. A plant located at Beaverton, Canada, at which this method has been employed is of interest not only for the process but also for the fact that it has been in successful operation for four years. The digging of the peat is done mechanically by an electrically-driven scraper which cuts and elevates the peat from any depth of the pit. The fragments are delivered before a paddle-wheel, which throws them in a shower over the cleared surface of the bog 30 to 50 feet, forming a layer of a depth of ½ inch, where it is dried by the air and sun. This layer may be built up by further increase to a thickness of 6 inches. The drying goes on rapidly if the weather is good, and a layer of 1 to 2 inches thick will lose 40 per cent in moisture in two to three hours. The material after drying is raked together by hand and loaded into electrically-driven cars, which carry it to the bins or hopper. From the hopper it goes to the "breaker" where it is further broken and delivered to the drier. This is a steel cylinder 30 feet long, 3 feet in diameter with a pitch of 14 inches. It turns at the rate of 1½ revolutions per minute. The interior surface is furnished with projections which assist in mixing the charge and preventing its sliding. The cylinder is surrounded at a little distance by a brick wall. The space between the wall and the cylinder is the flue for the passage of the hot gases. The peat passes through the drier in 20 to 30 minutes and falls as a pulverized mass upon a conveyer, which delivers it into a hopper at the briquetting press. The plant operates only in the summer time. It has a capacity of 12 to 15 tons per day, at a cost of $1.80 per ton.

Ex-pressed Peat.—The typical machine used is similar to the auger brick-machine. It consists essentially of a horizontal or a vertical cylinder on the axis of which is a shaft furnished with broad blades having cutting edges. The size of the cylinder, the number and the dimensions of the blades are determined by the character of the peat and they in turn influence the amount of output. As the shaft rotates the peat is crushed, torn and mixed, and moved forward by the blades which are arranged nearly as a spiral. The comminuted mass is finally forced out as a continuous bar through a die having one or more openings. It is cut into briquettes of convenient length and carried to the drying floor. The dry briquettes have one-fifth of the volume of a similar weight of raw peat. Small machines are operated by horse-power, the larger by steam. Sometimes auxiliary rollers for a preliminary crushing and cutting are placed above the main shaft. These machines are often mounted on trucks, which move along tracks on the bog, and a leg provided with a chain elevator reaches down into the trench. The laborers feed the cut peat on to the elevator, which conveys it to the hopper of the machine. The capacity claimed for the horse-driven machines varies from 8,000 to 20,000 bricks a day. The power machines deliver as high as 80,000, with a maximum consumption of 13 horse-power.

This type of machine has been in use for upward of fifty years, and hundreds are said to be in use on the continent of Europe. On the great bogs of Russia it is reported that 50 to 70 may be seen at work at a time,[13] each machine being driven by a locomobile of 12 horse-power, requiring the labor of 30 men, with a daily output of 40 to 60 tons in the dry state. The cost of production in Germany, with wages at $1 per day, is stated by Hall and Tolman[14] to be $1.70 per ton.

At New Rochelle, N. Y., an attempt was recently made to utilize local peat beds. The peat was prepared in this manner, but the machine in this instance was mounted on a track at one side of the trench and the bricks were distributed about the surface of the bog for the drying. Subsequently these were gathered and stored for sale. A number of tons were disposed of for local domestic use, and it was found very satisfactory when burned in open fire-places, and in some instances in kitchen ranges.

The quality of the peat produced by any of the above methods will depend primarily upon the completeness of the preliminary disintegration. Peat molded either by compression or expression is a very superior article as compared with the hand cut. It is so tough as to resemble wood in its resistance to cutting by saw or knife. It will not soil the hands nor crumble, which, together with its greater density, renders it suited for transportation. It resists weathering, as it is quite waterproof, and moreover it is not damaged by frost. As a fuel it burns slowly and steadily. Such methods of manufacture make peat a more available fuel, but do not increase its power to do work, since this is dependent upon the chemical composition alone. A pound of cut peat does not make as good a fuel as the more compact form, for reasons already mentioned, but it has the same heating power.

The drying of pulped or of ex-pressed peat is usually and most economically done by the action of the sun and air, either in the open or under sheds. A great deal of ingenuity has been displayed in the many devices put forward for the manufacture of peat fuel. For the most part they have been failures both in this country and abroad. It is estimated that fully $400,000 was spent in futile experiments in Canada in the space of seven or eight years prior to 1902. The fact remains, however, that the industry has been made profitable abroad, where the economic conditions are somewhat different. In general, without respect to location, certain conditions must be met in order to insure success. Bogs are not alike, and what is suitable for working one will not necessarily do on another. Advice from an experienced or competent person should be had in the selection of the bog, the method of operation, the choice of machinery and its installation. A preliminary survey of the bog will determine whether its extent and depth are sufficient to justify mechanical working, and physical and chemical examinations will settle the question of its usefulness and for what purpose. Bogs suitable for working with a permanent plant should have an area of at least 100 acres and a depth of at least 4 feet. Such a bog will yield about 70,000 tons of dried peat.

Kiln-dried Peat.—Experiments made for the purpose of removing the moisture held mechanically even by the driest peat by heating it in ovens or retorts have not produced a product of sufficient value to justify the expense. The early efforts were in the line of heating the peat in retorts either by applying the heat externally or by conducting the hot gases through the charge. It has recently been proposed to heat the peat electrically, either by piling the briquettes about a resistance coil in a closed chamber or by putting the peat in the circuit, with the expectation that a charring will follow.

Peat Coke.—For many years peat coke has been used in Europe for metallurgical operations, although at present there are only a few plants, owing to the close competition of coke. The Russian government has been reported as having recently built a factory between St. Petersburg and Moscow, in a region where coal and wood are scarce, for the purpose of providing fuel for locomotives. Owing to the normally low content of sulphur, peat coke has been highly esteemed in metallurgy, either alone or mixed with charcoal.

The methods used in coking may be classified as follows:

1. In heaps, as charcoal is made. A portion of the charge is burned to furnish heat for the coking.

2. In permanent kilns. A portion of the charge is burned.

3. In retorts. The peat is protected from contact with the flame or gases, and there is no loss by combustion.

Coking in retorts is the most important of the above methods, since it furnishes a greater yield of coke, and the by-products, such as gases, tar, acetic acid, etc., may be recovered. The Ziegler process, in operation at Oldenburg, Germany, is the most conspicuous example of this type. This plant with its five kilns has been in operation for several years, and has been reported favorably by German government experts. Another plant of the same kind is in operation at Redkino, in Russia, and at Beuerberg, Germany. The oven consists of vertical retorts made partly of iron and partly of fire-clay. These are heated by an upper and a lower bank of fire-places. The temperature maintained is 600 deg. C. The gas generated in the process is partially consumed under the retorts for coking, and the excess is used under the boilers. This gas furnishes enough fuel save that needed in beginning. The waste heat of the flue gases is used to dry the wet peat preparatory to use. The products of the coking are:[15]

27 per cent coke.

4.5 per cent tar, contains { Oil, Creosote, Paraffin.

31 per cent tar water, contains { Ammonia, Acetic acid, Methyl alcohol.

37 per cent gas, which contains 15 per cent methane and 24 per cent hydrogen.

About 18 tons of coke can be produced in 24 hours. Three tons of peat are required to yield 1 ton of coke. The coke is jet black, resonant when struck, firm, columnar, free from phosphorus and sulphur. Its thermal value is 6,776 to 7,042 calories. It sells for $9.52 to $11.90 per ton, and is highly prized for smelting iron, copper refining and similar purposes.[16]

An electrical process of coking was in operation in 1898 at Stangfiorden, Norway. The peat briquettes were loosely piled in an iron cylinder about a resistance coil. The dimensions of the cylinder were 3 feet by 1 foot. Nearby water-power was the source of the electric current used in raising the temperature of the coil. The peat was first partially dried and pressed into briquettes, and then thoroughly dried in a tunnel drier before going to the retorts. The by-products recovered were:[17]

Coke, 33 per cent; tar, 4 per cent; tar water, 40 per cent; gas, 23 per cent.

Peat coke or semi-coke has been prepared by passing the air-dried material between heated iron rollers or plates or through hot presses.

Peat suitable for the production of coke for metallurgical purposes should be of the dense variety with an ash content not exceeding 10 per cent. The ash, moreover, should not contain either sulphur or phosphorus, both of which, however, are only occasionally found in peat. Hand-cut peat furnishes a brittle product, and in general the greater the condensation peat can undergo in the process of manufacture the better the quality of the coke. The following table gives a comparison of various coked fuels:[18]

	Calorific Value.	*Calorific Intensity.*
Pure carbon (8,080 calories), ...	1	.....
Peat coke, ...	0.33 — 0.85	2,050 — 2,400
Wood charcoal, ...	0.64 — 0.97	2,100 — 2,450
Coke, 5% ash, ...	0.84 — 0.97	2,350 — 2,450

The only place known to the writer where coking of peat is being done in this country is at New Haven, Conn. There a small plant is offering its product at $9 per ton for household use, in competition with cannel coal at $12 per ton.

Peat Gas.—This is said to have been used for the past thirty years at the Notala Steel Works, Sweden. From 13,000 to 16,000 cubic yards of dry-kneaded peat are annually consumed. It costs somewhat more than coal gas, but has the great advantage of containing little, if any, sulphur or phosphorus. It is also reported that gas is used at several places in Europe for heating purposes, and in some glass-melting furnaces. One of the advantages offered by this use of peat is the opportunity to utilize material having a high content of ash. The usual method employed produces what is known as generator gas. The operation is so conducted that a very thick bed of fuel is always present and the combustion takes place in such a way that it is incomplete. Instead of the gaseous products being consumed, i. e., oxidized, a large portion escapes in a combustible form and is conducted to the place where it is to be used as a fuel. In the following table there is a comparison of generator gas made from different fuels.[19]

	Peat.	*Lignite.*	*Bituminous Coal.*
Carbon monoxide, ...	21%	22%	22%
Hydrogen, ...	8%	8%	9%
Hydrocarbons, ...	2%	2%	2%
Nitrogen, ...	60%	62%	61%
Carbon dioxide, ...	9%	6%	6%

It has also been proposed to use peat for the generation of water gas, since the large amount of moisture present in the raw material would be a positive advantage. It also seems probable that by the use of the Mond gas process the nitrogen present in peat may be profitably recovered. By this method coal containing 1.45 per cent of nitrogen will yield 70 to 75 pounds of sulphate per long ton.[20] Peats may readily be had containing this quantity of nitrogen.

The use of peat for the suction gas engine is said to have given satisfactory results. This may prove a most important field of usefulness for this fuel. According to Dr. Gradenwitz, "Even very low grade of material containing 50 per cent of water proved quite available, warranting the same safety of operation as any other solid material."[21]

The peats used for experiment had the following composition:

	Hannover.	*Grengen in Wurtenburg.*
Water, ...	32.30	4.78
Ash, ...	3.26	44.42
Calories, ...	3,596	2,392
Gas per Kilogram, ...	1.86 cu. meter	1.32 cu. meter
Calorific value of the gas, ..	1,429	1,350

The consumption of fuel, per effective horse-power hour, was 1.82 pounds and 2.71 pounds, respectively.

(To be continued.)

[13] Engineering Magazine, vol. 24, 1902, p. 204.

[14] Engineering Magazine, February, 1905.

[15] Engineering Magazine, 27:827.

[16] Special Consular Report, xxvi., p. 81.

[17] Hausding, Handbuch der Torfgewinnung, Berlin, 1904, p. 392.

[18] Hausding, Verwertung des Torfes, Berlin, 1904, p. 408.

[19] Hausding, Verwertung des Torfes, p. 415.

[20] Journal of the American Chemical Society, vol. xxvii., 1905, Review of American Research, p. 578.

[21] Lignite Producer Plants, SCIENTIFIC AMERICAN SUPPLEMENT, October, 1905, p. 24900.

[Continued from Supplement No. 1626, page 26048.]

CORN-HARVESTING MACHINERY.*

By C. J. C. Zintheo.

The Corn Shocker.

It is a curious fact that although earlier efforts were centered upon the construction of the corn shocker, the perfection of this machine was delayed until after the introduction of the corn binder. In the first machines the inventor attempted to engage the stalks by extending rods or springs in advance of the cutting knives, but this did not prove as successful as did the dividers of the corn binder. With these the corn could readily be brought to an erect position and thus made into a perfect shock.

The present form of shocker (Fig. 12) consists essentially of the dividers already described in connection with the corn binder, a revolving table for assembling the shock, and a crane for removing it. The knives and fly-wheel attachment for cutting the stalks, and the arrangements for raising or lowering the dividers, and the frame are similar to those used on the corn binder. The table revolves in the direction indicated by the arrow, and receives its motion from a bevel gear driven from the main drive and meshing into a rack on the outer edge of the table. As the machine advances the stalks are carried through the opening in the guard band. They are then caught by the spiral plates and the arms and forced around the central post. The arms also revolve, receiving their motion through the central pin from a gear located just beneath the table. Their motion is somewhat slower than that of the table. The guard or tension springs keep the stalks firmly compressed about the central post. Sometimes the twine is tied to one of the arms and allowed to assist in bringing the stalks toward the center by being wound about them as the arms revolve. This practice adds to the expense of operating the machine and does not materially improve the character of the work. At the outer edges are posts which support the tension springs.

When the shock is fully assembled on the table it must be tied by hand. The shock may then be raised from the table by turning the crank, and winding the rope about a spool. The shock must be lifted high enough to clear the retaining wall. The tension springs are swung aside and the crank acting on a sector gear instant the rope is given slack. This release of the arms is brought about by a unique arrangement of a cam and pawls. When the rope is tight owing to the weight of the shock, the pawls are held in the grooves of the cam because the weight is carried from the

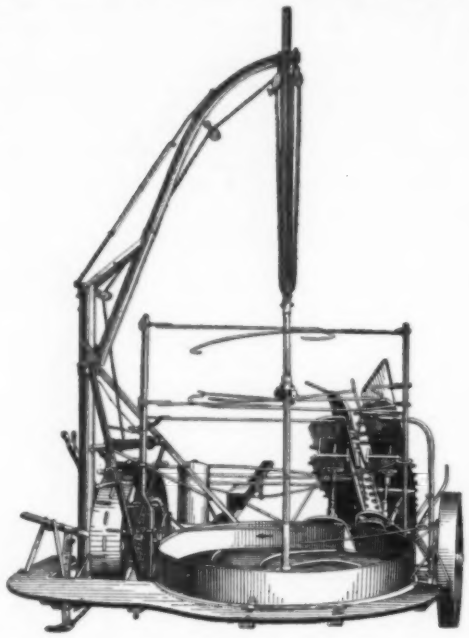

Fig. 12.—CORN-HARVESTER AND SHOCKER.

pulley. When the rope is given slack the pawls are no longer kept from slipping out of the grooves in the cam, the shock moves through a small arc of a circle and drops to the ground. The central supporting post is raised to its position on the machine, as shown in Fig. 14. The whole operation of forming, tying, and setting a shock can be done in five minutes. The admits of the low cutting of the stalks. This results in a greater weight of fodder per acre and leaves a short stubble that is easily turned under at the spring plowing.

Cost and Efficiency.—Corn shockers cost about as much as corn binders and weigh approximately the same. The wear and tear on the shocker is probably not so great as on the binder, and the former has the added advantage of requiring the work of but one man, whereas the binder requires, besides the driver, two or three men to follow and set up the shocks. The use of a corn shocker removes much of the hard labor of farming. Shocking corn is generally considered hard work and farm hands employed only for that purpose demand a good price for their services.

From the replies to questions asked in order to obtain a comparison between the merits of corn binders and corn shockers and from personal knowledge acquired in the field, it has been learned that the corn shocker seems to be the machine that meets the requirments of owners of small farms who do most of their own work. It requires a man of more ability to run a corn shocker than is required in operating a corn binder, on account of the numerous movements that the operator has to go through, all at the proper time, in removing the shock from the machine. The time of five minutes is about the average required for making the shock, half of this time being occupied in stopping the team, tying the top, lifting the shock, swinging the crane, releasing the core from the shock, and returning it to the table.

Recently patents have been issued for a horse-power lifting attachment for shockers, which consists of a folding tongue, to the top portion of which the whiffletrees are attached. To these is attached a cable, which is wound around a drum, the other end being attached to the lifting device. When the shock is ready to be lifted, a spring catch is released and the horses started forward. The machine remains stationary, but the forward movement of the horses lifts the shock by means of the cable, from the table. When the core has been returned to the table the horses are backed up to their former position, and the spring catch fastens the tongue in place ready for the forward movement of the machine. The addition of such a device will greatly reduce the work of the operator.

In the replies to the questions it is found that the

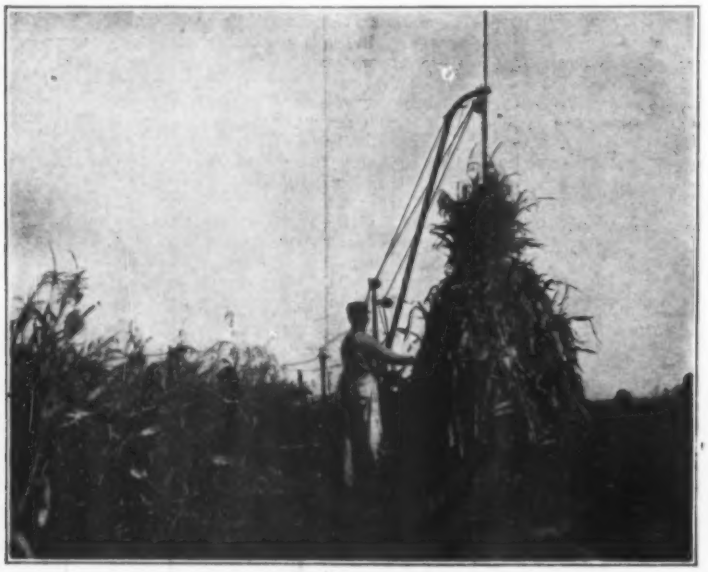

Fig. 13.—CORN SHOCKER UNLOADING THE SHOCK.

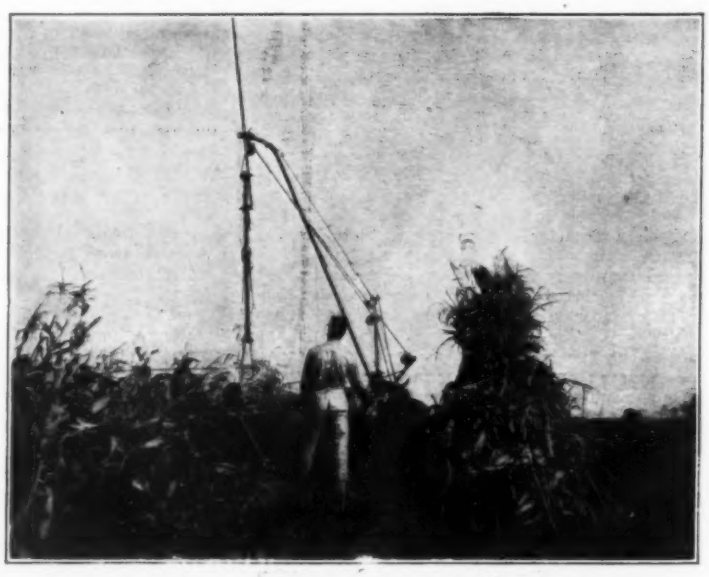

Fig. 14.—CORN SHOCKER RETURNING THE CENTRAL CORE

Fig. 15.—CORN-SHOCK LOADER, LOADED.

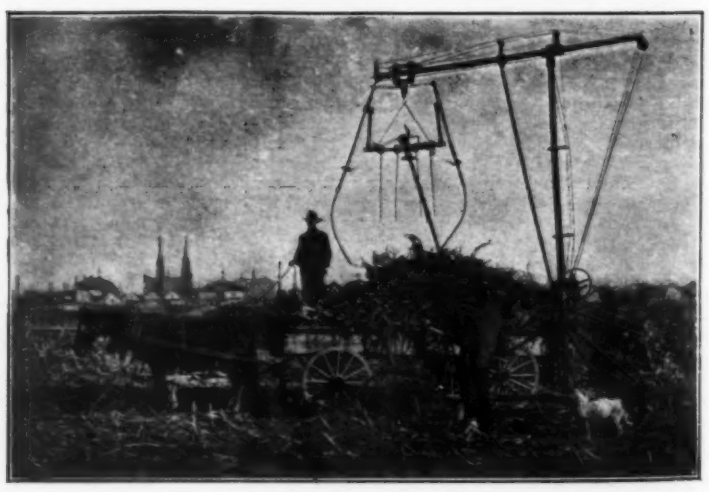

Fig. 16.—CORN-SHOCK LOADER, EMPTY.

swings the shock free from the machine, as shown in Figs. 13 and 14.

The arms (Fig. 12), which are held in a horizontal position by the weight of the shock, are released the shocks are somewhat smaller than those ordinarily made where corn is cut by hand or with a binder, averaging about 100 hills per shock, but the smaller size is necessary and makes it possible to reduce the weight of the machine. The smaller shocks also tend to cure more rapidly. The adjustment of the frame average number of acres of corn which can be cut per day with a corn shocker, three horses, and one man, is 4.7 acres. The life of the corn shocker, in years and acres cut, has not been ascertained, but as the wear and tear is less than on a corn binder, the life of the machine ought to be greater. Assuming that the al-

* Abstracted from a bulletin issued by the Office of Experiment Stations, United States Department of Agriculture.

lowance for first cost, life of machine, and interest on investment is the same as that for the corn binder—i. e., 29 cents per acre; allowing $3.55 per day for driver and team, or 75 cents per acre; and estimating that the twine required per acre cut with the shocker will not cost over 2 cents, we have a total cost of harvesting corn with a corn shocker of $1.06 per acre. This compared with the cost of $1.18 per acre for harvesting with a sled harvester, and $1.50 per acre for corn binders or by hand, gives quite an advantage in favor of the corn shocker.

The manual labor in harvesting corn is the least when using the shocker.

The general verdict of farmers who have used both the corn binder and the shocker is that the shocker is the preferable machine for harvesting corn.

A Corn-Shock Loader.—A loading device for handling corn shocks adds greatly to the value of the shocker, for with it the corn can be more cheaply handled than by the present methods. One of the first devices of this kind consisted of a long pole or pipe supported on a fulcrum at the rear end of the wagon in such a way as to give considerable leverage. The idea was much like that of the old well sweep with the semirotary motion added.

An improved loading device which can be carried along with the wagon or left in the field and driven about independently, has been invented (Figs. 15 and 16). It is mounted on four wheels and consists of an adjustable vertical mast on which is a horizontal steel cross-arm. On this is mounted a traveling block fitted with pulleys, through which a rope passes. To the end of this rope is attached a horse, which lifts the load. For loading corn shocks, a grapple fork is used, which is slipped under the shock. The grapple arms are closed and with the pull of the horse the shock is lifted up on the wagon and laid on its side or stood on end, the grapple arms being released by simply turning the handle of the fork. This machine was originally designed to load corn shocks, and it easily handles two shocks per minute, and will bear a stress of 2,000 pounds. It can also be applied to many other uses on the farm, as well as commercial uses, such as loading hay, manure, small grain, and other heavy objects on the farm; and for loading dirt, lumber, or telephone poles. Some form of loading device will greatly reduce the hard work on the farm and will be the means of rapidly introducing the corn shocker.

Corn Pickers.

In the so-called "corn belt," where corn is the principal crop raised, it has not been possible so far to utilize all of the cornstalks, as there is not enough live stock to eat them. The crop is raised for the ears, which are picked by hand at maturity. A wagon is driven along the rows of corn and one or two men walk along the rows, husk the ears from the stalks, and toss them into the wagon. It is estimated that 50,000,000 acres of corn are annually gathered in this way. This is somewhat tedious work. It is usually done after the other fall work on the farm has been finished, at a time of year when the weather is often cold and disagreeable. It is often difficult for the farmers to secure capable men to do this work at the time they are needed, even at good wages. To relieve them, inventors have been busy for over fifty years trying to build and perfect a machine to pick the corn from the stalks.

Description.

The first machine for this purpose was invented by "Father Quincy" in 1850. The picking mechanism of his machine consisted of a revolving cylinder on which were placed four rows of projecting metallic fingers placed at such a distance apart as to permit of the passage of the stalks but not the ears; these were snapped off and were received on an inclined conveyor belt which discharged them into a spout, from which they slid into a wagon driven alongside of the machine.

All of the early machines were designed to be pushed from the rear and were provided with some form of dividers to guide the corn to the snapping devices, as shown in Fig. 17. The snapping-roller type of corn

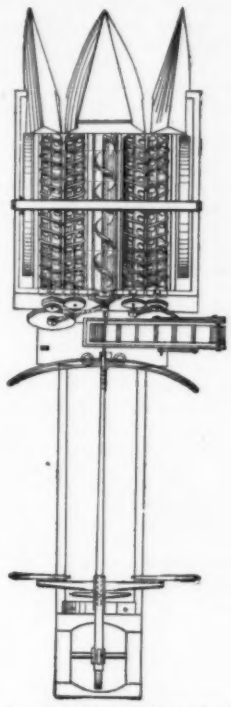

FIG. 17.—A CORN-PICKING MACHINE.

picker received serious attention from manufacturers about 1874, when the first machine of this type was invented, but it was ten years later that it was patented. The rollers were placed in the inclined position for the stalks of corn to pass between them. The end portions of the rollers where the stalks entered were provided with bars designed to aid in snapping off the ears as the stalks passed down between the rollers during the advance of the machine. For the remainder of their length the rollers were so constructed as to tear the husks from the ears and continuously feed the ears along to be finally discharged, husked, onto a conveyor, and delivered into suitable receptacles. This particular machine was thought to promise success, but when the corn binders began to be developed and came into use the interest in corn pickers abated, as it was thought that with a successful corn binder there would be no need of corn pickers. However, the use of the corn binder and the shocker, while quite extensive, does not solve the corn-harvesting problem in the purely corn-raising regions, where a large share of the corn is still picked by hand from the stalks as they stand in the field.

About 1902 the attention of manufacturers was again turned to corn pickers and several machines are now being introduced for picking corn. The corn picker as now constructed resembles the corn binder in the construction of the main frame, drive wheels, and dividers. It passes along the row of corn, which is straddled by the dividers, and the stalks after being righted by the points, chains, and other devices, pass between a pair of inclined, corrugated rollers that snap or strip off the ears. The rollers are positioned so that the ears fall naturally into a trough that extends along beside them. In order to provide snapping rollers to remove the ears and force them to fall always to the same side, yet permit free entrance of the upright stalks at the receiving end without the necessity of auxiliary means to bend the stalks laterally, James E. Goodhue arranged the snapping rollers in slightly skewed relation, by which the upright stalk may be gradually forced to one side as the picking rolls pass along, and the ears are broken off and directed to one side. The ears are carried back by a traveling conveyor and either delivered to a set of husking rolls or else, without being husked, carried by an elevator and delivered into a wagon which is driven alongside the machine.

Another form of modern practical corn picker has the guide chains with the usual prongs for straightening up the stalks. The chains form a stalk passage extending rearward through the machine. A rapidly moving chain provided with fingers is located at one side and between the guide chains in such a position that as the machine passes over the row the fingers engage the ears on the stalks and snap them off. By means of a deflector the ears are directed to a receptacle from which they are carried to the husking rollers and thence to the wagon. The tops of the cornstalks are cut off, and by means of a conveyor this and other trash is carried to the rear and dropped on the ground. This machine is shown in Fig. 18.

Objections and Advantages.

The corn picker is intended to remove the ears from the stalks, which are left in the field. Most of the machines are built on the assumption that the stalks are valueless, and therefore they are practically destroyed. It has not been possible to construct a picker that will not to some extent break down or tear down the stalks. This is somewhat objectionable because, where the corn is picked by hand, the dried corn leaves and stalks serve as roughage for cattle during the fall and winter. The machine has, however, this advantage, that the field can be picked quicker and the cattle turned in earlier to make use of the roughage before the snow falls.

Another objectionable feature of the corn picker as compared with the hand method of picking corn is that it shells considerable corn; and, if the corn is lodged and tangled, more or less ears are missed by the machine. The corn picker with the husker attachment requires considerable motive power, at least four horses being required to pull it. For this reason some manufacturers have dispensed with the husking attachment and depend upon the snapping rollers for removing most of the husks. Machines of this kind will remove from 25 to 75 per cent of the husks, depending upon the stage of maturity of the corn, the brittleness of the stalks, and the effects of freezing and damp weather. Where machines without the husker attachment are used, a stationary husker may be provided at the crib, in which the corn is husked and elevated into the corncrib.

There is a variance of opinion among the farmers as to the advisability of husking the ears clean. In the South the common practice is to leave the husks on the ears, and it is claimed that this practice tends to prevent injury by insects. In the North it is the common practice to husk the ears clean before they are cribbed.

The objections offered, in reply to inquiries, to using a corn picker which leaves the husks on the ears are that more crib room is required for the ears; that they will serve to attract and harbor rats and mice; that the ears will not dry out, but will be liable to mold; that the husks interfere with the shelling; that, while for feeding cattle and hogs the husks will be advan-

FIG. 18.—MODERN CORN PICKER.

tageous as they will serve as a roughage, horses will toss the ears in trying to remove the husks, and thus lose ear and all. For selling purposes the corn needs to be husked clean in order to command the best market price.

The economic side of corn pickers may be profitably considered. The corn picker should last about as long as the corn binder, or 8.17 years, and pick about the same number of acres per day as can be harvested with a corn binder, or 7.73 acres. The first cost of the machine is, however, practically twice that of the corn binder, or on an average, $250. This makes the cost of machine, interest on the investment, and repairs equal to 58 cents per acre. The cost of driver and team is $3.55 per day, or 46 cents per acre. There is required two wagons with teams to remove the corn from the machine and deliver it into the crib, which, at $3 per day for each, costs $0.77 per acre, or a total of $1.81 per acre for picking corn with a corn picker.

The corn picker is still an experimental machine. There are a number of problems to solve before a wholly efficient picker will be produced. The advisability of a farmer purchasing a corn picker is a question which each farmer should decide for himself. He may safely follow this general rule in the purchase of farm machinery and implements of all kinds: A machine newly put on the market, no matter how promising, should not be purchased by a farmer on ordinary terms, because, even with the greatest care on the part of the manufacturer in designing and constructing the machine, weak points in operation and construction are bound to develop, which it will take the manufacturer several years to overcome. Not until the machine has been perfected should the farmer purchase it. It is best to allow the manufacturer to do his own experimenting. If special arrangement is made whereby the farmer is compensated for aiding the manufacturer in developing the machine, that is a different matter.

(To be continued.)

ANNUAL REPORT OF THE SECRETARY OF AGRICULTURE, 1906.

Secretary Wilson in presenting to the President his tenth annual report takes occasion to indicate the position of the producer from the soil in the development of the country. He reports him as making progress in the sciences and arts of agriculture, aided by the researches of the Department of Agriculture and of the experiment stations, and states that "the time of the man and the yield of the acre become more responsive as more imperative demands are made upon them."

Enforcement of New Laws.—The laws made by Congress at its last session, to be executed by the Department, have required and received special attention. The meat law is being enforced, and inspection is now made in over a thousand houses. Not less than thirteen hundred experts have been added to the inspection force. Rules have been prepared for the execution of the pure-food law. Good has followed the operation of the law for the extermination of the cattle-fever tick in some of the Southern States. In dealing with the gipsy and browntail moths of New England, imported parasites have been successfully established. A beginning has been made in the method of determining the grading of grain, and the law providing for the humane treatment of live stock in transit is receiving careful attention.

Estimated Value of Farm Products.—The economic revolution in the art and science of agriculture continued during 1906, with tremendous results on the national prosperity. The value of crops continues to rush forward beyond comprehension; crops are straining the freight-carrying ability of the railroads; and the farmer, alive to the importance of the place that he occupies in the nation, offers this yearly account of himself to the people. The Secretary premises that the figures presented in his review of the year's full production are advance estimates preliminary to those to be made later by the Department. Estimates are made for comparison with every detail presented by the census. The farm products of the year have a farm value of very nearly six thousand eight hundred million dollars, nearly half a billion above the value of 1905 and exceeding by over two billion dollars the figures for the last census.

Value of Leading Crops.—Corn remains by far the most valuable crop, estimated at eleven hundred million dollars. Next comes the cotton crop, which, including seed, should be worth to the growers nearly six hundred and forty million dollars. The value of hay, which is third in order, approaches six hundred millions. Wheat, the fourth crop, may be worth four hundred and fifty millions; oats, three hundred millions; potatoes, one hundred and fifty millions. Barley, with a value of sixty-five million dollars, shows a gain of 21 per cent in production in the past seven years. The tobacco crop will be worth about fifty-five millions. A remarkable development is that of the sugar beet, now the ninth crop in value. The production in 1906 is placed at three hundred and forty-five thousand long tons, valued at thirty-four million dollars. Seven years ago the value of this crop was seven million dollars. The value of all kinds of sugar, syrup, and molasses aggregates seventy-five million dollars.

High Total Value.—On the whole, crop values have been neither notably high nor low in comparison with recent years, but the high price level in the general average has raised the total crop value somewhat as compared with 1905 and the high preceding years. To reach a still higher point in this series of high annual values is an achievement worthy of attention.

Agricultural Exports Exceed All Former Years.—The farm still overshadows the mill, the factory, and the workshop in providing exports, and with his surplus beyond the nation's need the farmer has loaded the fleets of oceans. For the fiscal year ended June 30, 1906, this surplus has been exported to the value of nine hundred and seventy-six millions, the largest amount ever reached by agricultural exports for this or any other country and exceeding the export value of 1901, previously the record year. Among chief exports cotton maintains a long lead, with a value of four hundred millions. The packing-house products exported amounted to a value of two hundred and seven millions.

Imports of Farm Products.—The imports of agricultural products consist mainly of the same articles year after year and reached their highest value in 1906—five hundred and fifty-four millions. These included packing-house products, ninety-six millions; sugar and molasses, eighty-six millions; coffee, seventy-three millions; silk, fifty-four millions; vegetable fibers, fifty millions; wool, thirty-nine millions; tobacco, twenty-two millions; fruits, twenty-one millions; tea, fourteen millions. In forest products, 1906 shows an import value exceeding ninety-five millions, against a total value of exports of similar products amounting to seventy-seven millions.

Agriculture Becomes More Scientific as Need Arises.—The mighty production of the farmer for one-third of a century has come out of an agriculture having many faults, yet the course of agriculture in this country, unscientific as it may seem, has had economic justification. Pioneers, poor and in debt, have no capital, even if they have knowledge. They must have buildings, machinery, and live stock even at the expense of the soil. Moreover, millions of acres of fresh land have been coming into production faster than domestic consumption required. A more scientific agriculture would have raised crops in excess of the demands; but, when consumption demands and prices sustain, the farmer will respond, for the doors of knowledge and example are opening wider to him. No miracle would be required to double or even treble the production of cotton per acre. The corn crop can be increased by one-half per acre within one-fourth of a century and yet without reaching the limit, and the same may be said of wheat and many other crops. One-fourth of the dairy cows of the country do not pay for their feed, and more than one-half of them pay no profit. The egg production per hen will be increased by at least a dozen a year within a generation, while some poultrymen foretell double that increase. If the hens of this year had each laid a dozen eggs more than they did, the increased value of this production would have possibly aggregated fifty millions of dollars. The farmer will not fail the nation if the nation does not fail the farmer. He needs education to open the powers of the soil now hidden from him. The work of the Department has already had results valued at hundreds of millions of dollars annually and yet has barely crossed the threshold of its mission of discovery and education. Co-operating to the same ends are the experiment stations in every State and Territory, agricultural colleges, farmers' institutes, and many excellent agricultural publications and books.

Great Improvement in Farmer's Condition.—Cotton planters are now out of their former bondage to future maintenance, and in the Middle West there has been a conversion of a million agricultural debtors, paying high rates of interest, into financially independent farmers, debt-free and offering their savings to the banks at as small a rate of interest as 2 per cent. Farmers are using their new capital to abolish the waste places of the land and along many lines of improved production. Formerly there was an abundance of farm labor and a scarcity of farm capital. Now these conditions are reversed; labor is scarce and capital abundant.

SWINDLING ALCHEMISTS OF BYGONE DAYS.

By Dr. Stephan Kekule von Stradonwitz.

Alchemy is one of the most remarkable phenomena in human history. Beginning in the Middle Ages it continued to flourish for two hundred years after their close and was not entirely superseded by modern scientific chemistry until the nineteenth century.

The idea of the possibility of converting base metals into gold, or in other words, obtaining gold cheaply, had gradually become developed into an elaborate esoteric doctrine. It was conceived to be possible to produce a certain mysterious substance called "the great secret," "the great magisterium," or "the philosopher's stone," which should possess the property of changing common metals into gold. Another hypothetical substance was "the lesser magisterium," the power of which was limited to the transmutation of base metals into silver.

The philosopher's stone, which was nearly always imagined as a red powder, prepared with almost infinite difficulty, was endowed with many other marvelous properties, including that of curing disease and conferring longevity and even immortality, in addition to its gold-making peculiarity.

Gold has always been coveted as eagerly as it is to-day. What wonder, then, that alchemy and its chief object of research claimed the activities of high and low, rich and poor, princes, peasants, and professors, honest men, rogues, and adventurers, and produced some of the most astounding chapters of the history of civilization?

At almost every great court in Europe there was at least one period, of greater or less duration, in which swindling alchemists flourished exceedingly.

One of the most successful of these adventurers was Leonhard Thurneisser zum Thurn, who appeared at the electoral court of Brandenburg, at Berlin, in the sixteenth century.

Thurneisser was born at Basle in 1530. In his youth he was first a goldsmith, then a physician's assistant. From his eighteenth year onward he traveled extensively, entering the service of the Emperor Ferdinand and the archduke of the same name, and visiting Scotland, Spain, Portugal, Greece, and Italy. In the course of his wanderings he acquired an extensive knowledge of medicine and mineralogy. In 1570 he came to Brandenburg, where he attracted the attention of the Elector Johann Georg through a book which he published under the title "Piso," in which he asserted that the river Spree contained much gold, and that great quantities of rubies, sapphires, and emeralds were to be found in the Mark of Brandenburg by those who knew how to seek them. Thurneisser's first success was the happy cure of an illness in the elector's family, in consequence of which he was appointed court physician, with a salary of 1,352 thalers, clothing, fodder for four horses, and very spacious lodgings in the Gray Cloister, now used as a gymnasium, or college. He soon appears as a great man, clad in velvet and silk, attended by two pages, drawn by four horses, and possessed of much silver plate and great riches. He converted the Gray Cloister into a laboratory, collected books, weapons, natural curiosities, and specimens, established small botanical and zoological gardens and a printing press for the production of his own works in sumptuous style. His obviously very large income was derived mainly from the sale of wonderful remedies at fabulous prices. He also did a good business in horoscopes, amulets, and talismans. For some unaccountable reason he was twice, in the full tide of his success, seized with an irresistible desire to revisit his birthplace. The second visit was the cause of his downfall. He fell captive to the fascinations of a lady of Basle, whom he married, but he soon separated from her, and thereby became involved in a lawsuit in which he lost his entire fortune. In 1581 he reappeared in Berlin, but three years later he suddenly vanished again, this time forever. The most probable explanation of this final disappearance is that the climate of Prussia had been made too warm for his comfort by the Latin inaugural dissertation of the celebrated Prof. Kaspar Hoffmann, of Frankfurt, which, though not aimed directly at Thurneisser, made an annihilating attack upon his methods of healing. Thurneisser thereafter wandered from place to place and died in poverty in 1595, probably at Cologne.

Thurneisser was half scientist and half swindler; but another celebrated alchemist of Berlin was an out-and-out charlatan and adventurer. This was the Neapolitan peasant who assumed the imposing title of Don Domenico Manuel Caetano, Conte de Ruggiero.

Caetano, after beginning his gold-making career at Madrid, proceeded to Brussels, where he quickly won the favor of the Austrian stadtholder of the Netherlands, Elector Maximilian of Bavaria. Soon, however, he was thrown into prison, whence he escaped, entered the service of Emperor Leopold I., and subsequently that of the Elector of Pfalz. The honor accorded to such men in those times is illustrated by the fact that the Elector of Bavaria made Caetano successively a colonel, master of ordnance, field marshal, honorary governor of Munich, and state councilor. In 1705 Caetano, in a gilded coach, made his triumphal entry into Berlin. According to one chronicler, he was presented at court by the English ambassador, and gave proof of his powers by converting into gold the metal trimmings of a nobleman's liqueur case. This performance, with his pompous entry and his jewels, dazzled all eyes. The king invited him to the palace, and entertained him royally for twelve days. Then, in the presence of the king, the crown prince, and many high dignitaries, the "count" made a second experiment in gold making, which succeeded so brilliantly that his reputation was established, and he was thenceforth loaded with favors and honors. His subsequent career was like those of most swindling alchemists who have won royal favor. There came a day when the trick failed. The charlatan still demanded money, but produced no gold in exchange. He fell under suspicion, and in 1709, after a very summary trial, he was hanged on a gallows appropriately covered with gilt paper.

The three greatest swindling alchemists of history were the Count of St. Germain, Cagliostro, and a man whom it seems strange to find playing such a rôle, the amiable and amorous Casanova.

The Count of St. Germain is variously described as a Portuguese Jew, a Spanish Jesuit, an Alsatian, and the son of a Savoyard tax collector. He was born about the year 1700. After 1750 he is found moving in high society in different capitals under various names, and with the title of count, chevalier, or prince. In Paris he succeeded in gaining the favor of Madame de Pompadour. He was very successful in St. Petersburg, and later in Berlin, and ended his days in 1780, in the palace of the Landgrave of Hesse-Cassel.

St. Germain claimed to be able to make gold and jewels as well as a wonderful elixir, which would give to age the beauty and strength of youth, transforming a wrinkled old woman into a blooming maiden of seventeen. He asserted that this elixir had prolonged his own life for many thousands of years, that he had personally known Christ and the Apostles, and had enjoyed the intimate friendship of St. Peter. All of these amazing statements met with ready belief. An amusing dialogue, overheard and naively narrated by a chronicler of the court of Dresden, is worth repeating as an illustration of the credulity of even the

educated classes at that period. St. Germain's coachman, being asked if his master were really four hundred years old, replied that he could not say, of his own knowledge, but that, in the one hundred and thirty years of his service with the count, his master's appearance had not changed a particle.

St. Germain, however, was unquestionably a man of profound and extensive knowledge, brilliant intellectual gifts, and astonishing dexterity. Count Lamberg, an apparently trustworthy historian, says that St. Germain wrote, from his dictation, twenty lines of a well-known poem with the right and left hands simultaneously on two sheets of paper, and that the two manuscripts were so nearly identical that one could not be distinguished from the other. Questions and expressions of admiration evoked oracular utterances, which increased the charlatan's fame. He probably owed the lucrative friendship of Madame de Pompadour, the all-powerful favorite of Louis XV., to his ability to compound lotions, powders, ointments, and other preservatives of her waning beauty. The high favor in which he stood with the marchioness and her royal lover is evidenced by the grant of the magnificent palace of Chambord as a residence and an annual stipend of one hundred thousand francs. The king even made St. Germain a secret diplomatic agent, and in 1759 sent him to The Hague to negotiate a loan of a hundred million francs from the great Dutch bankers—in which mission, however, he was unsuccessful.

The so-called Count Cagliostro, whose real name was Giuseppe Balsamo, was born at Palermo in 1743. The memory of this remarkable man will be preserved in Germany, at least, by the interest shown in him by Goethe, who wrote a poem, though a very inferior one, "The Grand Kophta," inspired by his career, delivered a lecture on his pedigree, described, in the "Italian Journeys," his own meeting with the family of the adventurer in Palermo, and finally took a prominent part in his exposure.

Cagliostro's first prominent patron was the grand master of the Knights of St. John in Malta. Here, while occupying the post of chamberlain, he married a pretty maid servant. He next appears in Riga, where he played a very conspicuous rôle. Subsequently he formed an intimate association with the Cardinal de Rohan, in Paris, and thus became the principal actor in the tragi-comedy of the diamond necklace. Finally he was arrested in Rome and condemned to death, but his sentence was commuted to imprisonment for life. He died in prison in 1795.

Cagliostro appears to have been the most brilliantly successful exploiter of human credulity that the world has ever seen. Everywhere he and his beautiful wife drew usurious revenues, she from the fascination of her beauty, he from the sale of wonder-working elixirs, gold making, magic, and conjuration.

Jacob Casanova, the amorous rogue and irresistible lady-killer who assumed the title of Chevalier de Seingalt, was born in Venice in 1725, and died in 1798 in the castle of the Bohemian Count Waldstein, to whom he was librarian. His sensational escape from the "leads," or prison cells of the Doge's palace in Venice, has been made famous by his memoirs, which also contain many references to his real or pretended search for the philosopher's stone and the elixir of life. His most astonishing swindling exploit was the fraud which he perpetrated on an old and childish French lady, the Marquise d'Urfé, whom he persuaded of his ability to transform her into a young girl, by methods which now appear like the most childish folly, and thereby extorted from her nearly half a million francs. The marquise, who was seventy-three years old, had devoted her life to the study of alchemy. She had a great laboratory, to which she admitted only her most intimate friends, and here she passed her days and nights in seeking the philosopher's stone and endeavoring to compound the elixir of life. Casanova made her believe that, under the influence of the stars and cabalistic signs, she would die *in childbirth*, but would return to life, after the expiration of exactly seventy-seven days, as a maiden in the bloom of youth and beauty—provided that she should be fortunate enough to escape burial. The foolish old woman believed all this, and, as Casanova had the tact to avoid demanding cash and only asked for jewels, which he alleged to be needed for his alchemical work, she never refused his request.

Of material evidence of the powers of alchemy, that is to say, of gold produced by the transmutation of base metals, very little is now in existence. The treasure chests of royal families contain a few specimens, the most notable of which is the great "gold" medallion engraved with the family tree of the Hapsburgs, the production of the Vienna "court alchemist," who was regularly ennobled in 1676, under the title of Wenzel Seiler von Reinburg.—Translated for the SCIENTIFIC AMERICAN from Umschau.

WHAT DEMANDS ARE WE TO MAKE ON A SERVICEABLE PRESERVE GLASS?

THIS question is submitted to us repeatedly, as well on the part of the preserving industry as on that of the glass factories. We give below a few leading points, which on the whole may be said to represent the demands which the preserving industry requires a serviceable preserve glass to satisfy:

1. The glass must be provided with a simple sealing apparatus, although from the standpoint of hygiene and the technique of the preserving industry, it must be altogether unobjectionable.

2. The glass must be adaptable to the manufacture of preserves on a large scale, and be correspondingly cheap for wholesale consumption.

3. But little stress is laid by the preserving industry on the ability to use the glass again; on the other hand, it is greatly desired that the cover should constitute such a seal, that a jar containing the remainder of partly used preserves, in other words, broken contents, should be fully protected against contamination.

4. The glass must be made in such shape and out of such material that the contents present to the customer a qualitatively and quantitatively favorable appearance.

5. Such a shape should be given to the glass that it will be feasible to pack it for shipping purposes, with a minimum loss of room.

6. Whether a machine should be required for the sealing of the glass, or whether it is hermetically closed automatically, is of secondary importance for the preserving industry.

7. Such seals for the glass are to be preferred by the preserving industry which allow it to be recognized whether the contents of the glass are spoiled.

Of course, the foregoing points do not make the claim to be complete, nor to represent all the demands which we would require a serviceable preserve glass to fulfill. For the present, these short specifications are to present only generally essential points, and to serve the purpose of stimulating further expressions of opinion from actual practice.—Konserven-Zeitung.

TRANSPLANTATION IN SURGERY.

By PROF. GARRÉ.

THE field of surgical transplantation or grafting, at first confined to the skin, has widened with the development of the antiseptic method of operation so that it now includes many tissues and has recently been extended to organs. Tissues of all kinds, large sections of organs and even entire organs can be removed from their natural positions to other parts of the body, or to other bodies, and the wounds healed, but transplantation, to be successful and of utility, must go further than this. The transplanted tissue must continue to perform its normal functions.

Success depends on conditions of nutrition and the mass and tenacity of life of the tissue. It is most probable when the tissue is transplanted to another part of the body from which it is taken. If it is transferred to another individual the chance of successful transplantation depends upon the degree of relationship existing between the two. Transplantation from other animals to man is successful only in a restricted sense. The wound heals and the graft benefits similar tissues by supplying material for growth, but in so doing the graft itself disappears by absorption.

Let us first consider skin grafting. For the healing of wounds caused by operations and otherwise this is a simple, certain, and most valuable process. Large gaps in the skin, caused by burns, ulcers, abscesses, or the removal of part or the whole of the scalp—cases which used to defy treatment—can be quickly covered and healed by grafting.

The alteration which transplanted tissues undergo was strikingly illustrated by Thiersch's experiment of making an exchange of skin between a white man and a negro. In a few months after the operation the black transplanted skin had turned white and the white black.

The transplantation of mucous membrane is effected in a similar manner. It is practised chiefly by oculists, who have filled gaps in the conjunctiva with membrane from the labia minora and rectum. Membrane taken from rabbits has been used for the same purpose but is not permanent. Mucous membrane has also been transferred from the vagina to the urethra, and Woelfler has lined with membrane from the uterus a flap of skin cut from the forehead to replace a lost nose.

From grafting bits of the epidermis to transplanting large pieces containing all the layers of the skin was but a small step. It should be observed that the latter operation has long been practised, although it was justified and made orthodox only by Krause's improvements in method and modern aseptic surgery.

Pieces as large as the palm of the hand can be successfully transplanted under favorable conditions of nutrition. The glands and hairs of the transplanted skin retain their vitality, and in time nerves grow inward from the edge and re-establish sensibility.

Cartilage and bone can sometimes be successfully transplanted in connection with skin. In several recent cases the lower eyelid has been replaced by a part of the lobe of the ear, and Nicoladoni has succeeded in grafting the tip of a toe, split lengthwise, on a maimed finger.

Comparatively little has been done in transplanting adipose tissue, though Czerny has put a fatty tumor to excellent use by substituting it for the amputated breast of an opera singer.

Unfortunately, the results promised by Gluck's experiments in transplanting muscles and sinews in animals have not been obtained in human surgery. The voluntary muscles are absolutely dependent on abundant nutrition and very active metabolism, of which they cannot be deprived longer than two or three hours without serious injury.

The promises of certain enthusiastic experimenters in nerve grafting have likewise failed of fulfillment.

The transplantation of osseous tissue, on the other hand, has attained great importance in surgery. Bergmann replaced a section of the tibia, 3½ inches long, by a piece taken from the fibula. A year after the operation the junctions of the bones were scarcely discernible.

Entire metacarpal bones can be replaced by other bones of the hand or foot, which even increase in size if the periosteum has been transplanted with them.

The autoplastic method, in which the material is taken from the skeletal bones of the patient, has stood the test of practice. But it cannot be employed in all cases.

Success, though far less certain, has been attained with bone taken from other persons and even from animals. Bone taken from amputated limbs, infants that have died at birth, calves, lambs, dogs, rabbits, and geese have been more or less successfully grafted on living persons.

Now Barth has proved by exact experiment the surprising fact that bone removed from its place of origin always perishes. When transplanted it is overgrown and permeated by new bony tissue and gradually disappears by absorption, thus furnishing salts and other material for the new growth. So it is a matter of indifference whether the transplanted bone was human or animal, living or dead, and Barth asserts that bone ash is utilized as well as living bone for the construction of new tissue. Success depends, however, on two conditions: the site of transplantation must be capable of forming bone, and it must be aseptic. The difficulty of satisfying these conditions limits the field of employment.

These various methods of bone grafting illustrate the remarkable tolerance of foreign matter which is exhibited by living bone, a fact which surgeons have put to practical use. Cavities in bones have been filled with cement, gutta percha, dentists' "soft fillings," copper amalgam, plaster of Paris, and recently and very successfully with a mixture of iodoform and spermaceti which, like gypsum, is very rapidly absorbed and replaced by new bone. Holes in the skull have been closed with plates of celluloid; rods of ivory have been set in fractured hollow bones, and these bones have been fastened together with metal screws, pins and clamps.

Unfortunately such foreign bodies are seldom borne permanently. In many cases suppuration ensues years after the operation. Foreign bodies that are not absorbed usually cause disturbance, as the experience of a thousand years of military surgery has proved.

The transplantation of teeth, natural or artificial, is seldom successful. Numerous experiments in the transplantation of organs have recently been made. The study of cretinism and the discovery that the total removal of the thyroid gland produces idiocy suggested transplantation of the thyroid as a remedy for idiocy. A human or sheep's thyroid was transplanted aseptically, while yet warm, to the abdominal cavity, or under the skin, or upon an artery of the patient. In no case was a permanent cure effected, although many patients were benefited for six months or longer. Experiments on animals have proved that both the positive and negative results are due to the gradual absorption of the transplanted gland. When it is entirely absorbed the original condition returns.

The method would have been abandoned as hopeless had not Eiselsberg succeeded in transplanting the thyroid, in a cat, and preserving the functional life of the gland. Recently Payr hit upon the happy idea of grafting the thyroid on the spleen, which is very well supplied with blood. Last winter, encouraged by the success of his experiments on animals, Payr grafted part of a woman's thyroid upon the spleen of her four-year-old idiot child with the surprising result that now, nine months after the operation, the child is beginning to develop mentally and is learning to walk and talk.

Equally favorable are the chances of success with other glands of essentially internal secretion, including the thymus, the supra-renal capsules, etc.

With organs of both internal and external secretion, such as the testicle and pancreas, the problem is more complex, for a gland cannot retain its functional activity unless its external secretion can escape.

Organs of exclusively external secretion, such as the salivary gland, liver, and kidney, present difficulties of another sort. These organs are scarcely divisible and their life depends on an abundant supply of blood, which can be furnished only by connecting the blood vessels of the organ with those of its environment.

This presupposes perfect and certain methods of joining blood-vessels, a recent branch of surgery, inaugurated by Murphy. Two of the earliest successful junctions of human arteries were made by the writer only ten years ago. Since then I and my assistants have joined blood vessels, both arteries and veins, of a diameter as much as 1-20 of an inch, have joined arteries to veins and have transplanted sections of blood vessels as long as 2½ inches from one animal to another. The fact that we transplanted sections of arteries from a dead dog to a live dog without disturbing the circulation is important in connection with the source of material for similar operations on man. Sections of arteries cannot be taken from the body of the patient but sections of veins can be taken without injury and they may serve to mend arteries. Or the material may perhaps be taken from amputated limbs.

Our numerous successes in joining blood-vessels encouraged us to attempt to transplant kidneys. We succeeded in transplanting kidneys of dogs to the neck and the groin. The transplanted kidneys usually began to secrete at once. The secretion contained all the important constituents of urine, so that it appears that a transplanted kidney performs its normal function of removing poisonous matter.

The transplantation of blood-vessels and kidneys is a new fact of scientific interest and practical importance. A blood-vessel is not a mere conduit, but an organ with muscles and nerves intimately connected with the central nervous system The tissues hitherto transplanted with success are not so connected. It is also remarkable that we have succeeded in transplant-

ing the blood-vessel of a cat to a dog, although simple tissues transplanted from one species to another are always absorbed and replaced by new tissue, and thus serve only to furnish material and stimulate regeneration. Is this true of the blood-vessel also? I cannot think so, and in the case of so complex an organ as the kidney, which performs its functions as a unit, this process of absorption and replacement is impossible and inconceivable.

Furthermore, the transplanted kidney is withdrawn from the influence of the nervous system, yet it continues to perform its functions. Is this condition permanent? Can the transplanted organ indefinitely maintain its regulating action and adapt itself to the varying needs of the body? These and similar questions still remain unanswered.—Translated for the Scientific American from Umschau.

[Concluded from Supplement No. 1626, page 26053.]

ADVANTAGES AND APPLICATIONS OF THE ELECTRIC DRIVE.*

By F. B. Crocker and M. Arendt.

When the electric drive has been properly applied the advantages derived may be listed as follows:

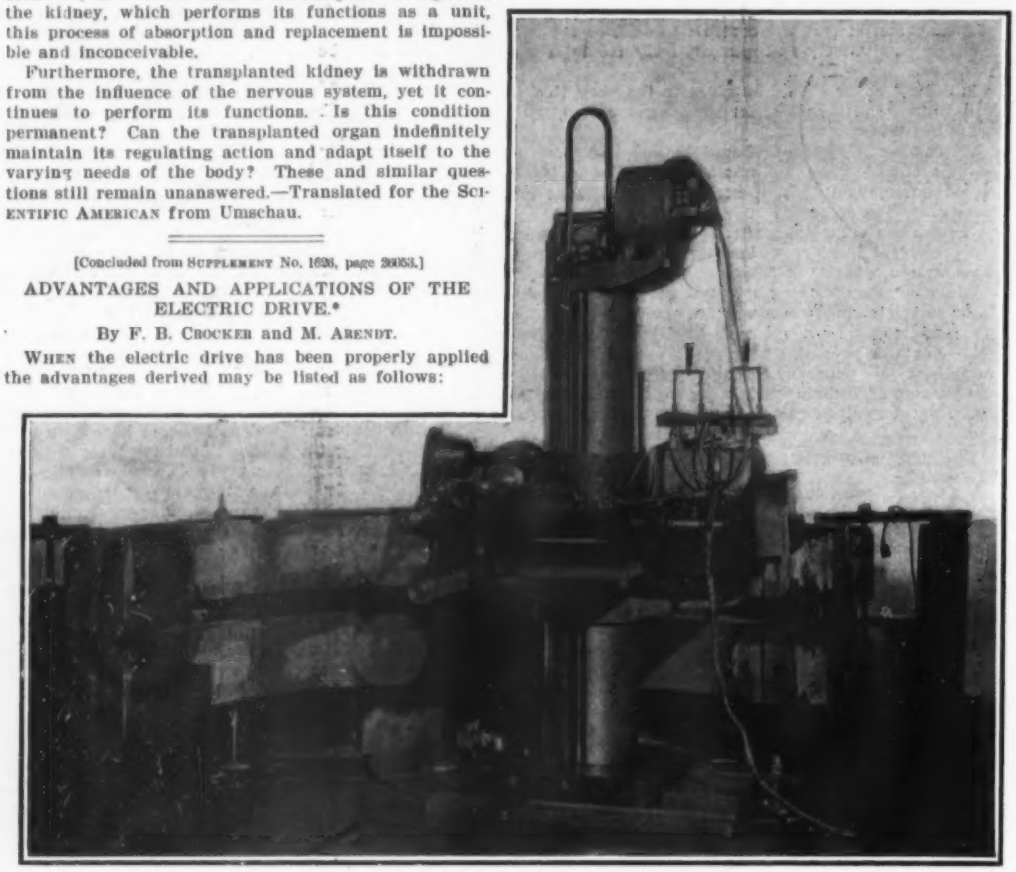

FIG. 11.—ELECTRICALLY-DRIVEN VERTICAL SHAPER.

1. Saving in Power.—This is generally the first point to be considered, but it is by no means the most important, as the cost of power in most factories is only one to three per cent of the cost of the finished product, the cost of labor being usually many times greater. It is a fact, however, that due to the absence of belting and shafting losses, and the cutting off of electric current whenever an individually operated machine is stopped, the saving of power is a much larger quantity than might be expected. In a paper before the American Institute of Electrical Engineers by R. T. E. Lozier, the following data was given:

"From the data that has been collected on power transmission in industrial shops, much of which is to be found in the transactions of the various engineering societies and in the magazines, it appears that if a certain maximum horse-power is required by all the tools of a shop, say 100 horse-power, it will require at least 100 horse-power additional to transmit this effective power by belts and shafting.* This loss of 100 horse-power remains constant whether the effective horse-power is reduced or not. This means that 200 horse-power must be generated. Should these same tools be driven by individual motors, instead of 100 horse-power being required for transmission only 43 horse-power is required, even if every tool is running; but it is found that in the average industrial shop every tool is not running at once, some being shut down and others operating on lower than maximum speeds, thus requiring less horse-power. It has been determined practically that in the ordinary manufacturing establishment the mean effective power is but 30 per cent of the total aggregate effective power which is required when all the tools are running at maximum load. This percentage is termed the load factor. In the case of belt-drive there is, then, 100 horse-power assumed loss for 100 horse-power effective load; that is, an efficiency of 50 per cent. Apply the load factor as above, it is found that there is but 30 mean horse-power to use and that it requires 100 horse-power to transmit it, thus giving the real efficiency as only 23 per cent. With the individual motor drive the loss varies with the load. Taking the same load factor, and assuming 30 per cent as representing the loss incurred by the 30 horse-power effective load, there is but 9 horse-power loss against 100 horse-power with the belt drive. Thus, with individual drive, there is generated 39 horse-power of which 30 is effective, giving an efficiency of 77 per cent against 23 per cent by the shafting and belting method."

* Portion of Lecture Notes on Electric Power. Electrical Engineering Department Columbia University. Published in the School.

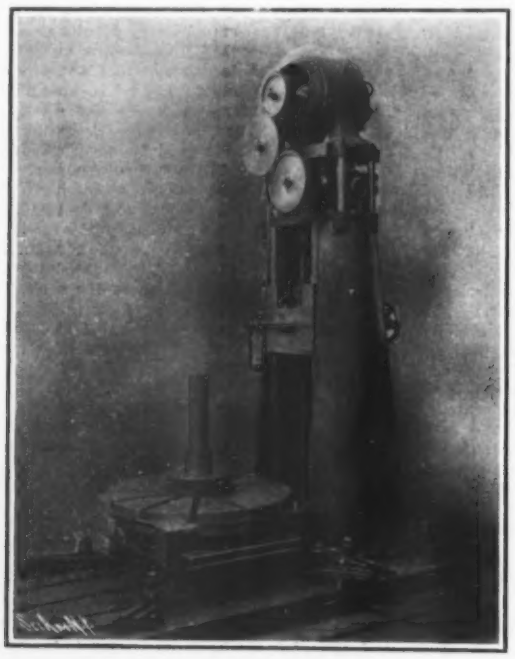

FIG. 9.—VERTICAL MILLING MACHINE.

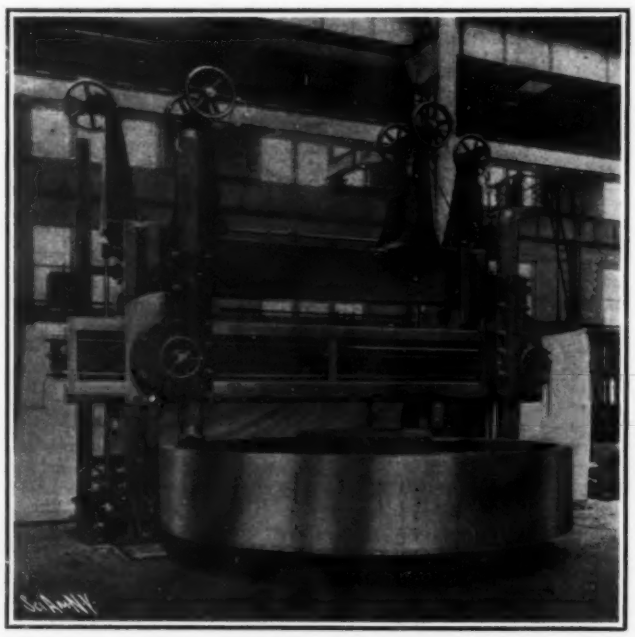

FIG 10.—VERTICAL BORING MILL.

2. Cost of Buildings.—Heavy overhead shafting is not required for the electric drive, hence the buildings may be made lighter and cheaper in construction, as settling will not throw parts of the equipment out of alignment and cause serious friction losses, vibration, etc.

3. Cost of Equipment.—The relative expense of equipping a factory with electric motors or with belting and shafting is usually greater in the former case, so that the saving in operation expenses or increased earning power must more than offset the increased interest and depreciation. On the other hand the lower cost of the lighter building construction balances more or less the cost of the motors.

4. Arrangement of Machinery.—The use of electric motors enables the machinery to be placed in almost any desired position. It is not necessary that they should be parallel or arranged in rows, or placed at any particular angle with each other, whereas for belting and shafting the machinery must be arranged in a very particular manner, and very often it has to be placed where the light is poor, or accessibility and other important features must be sacrificed. A great advantage obtained due to the flexibility of the electrically driven machines is that portable equipments are easily made up and operated, so that the tool is frequently brought to the object to be worked on, in place of bringing the work to the tool.

5. Clear Head Room.—The elimination of overhead belting and shafting through the use of motors gives a clear head room, which enables overhead cranes to be freely used; a fact which results in a great saving of time and labor in the bringing of the work to the tools or removing finished pieces, the value of which is apparent when one considers the time and labor necessary to bar along heavy machinery on rollers. The clear head room also gives better illumination and ventilation. In fact the saving in cost for proper illumination may amount to as much or even more than the saving in tool operating power; since general illumination may be largely resorted to. Fig. 12 shows the appearance of a machine shop operated by belting and shafting, and Figs. 13 and 14 are illustrations of a plant where the tools are operated electrically, the great advantages regarding head room and illumination being well brought out by these two examples.

6. Cleanliness.—The dripping of oil from overhead shafting is a constant source of annoyance, and the dirt thrown out from belting is an even worse enemy to cleanliness. The agitation of dust by belting and shafting keeps it in constant circulation, so that it penetrates everything and everywhere. This is a very important matter in printing and textile work.

7. Health of Employees.—On account of the better ventilation and illumination, and reduction in dust and dirt, it is shown by actual experience that the general health of those who work with electrically driven machinery is improved. In the government printing office at Washington, it was found that the sick list was decreased about 20 to 40 per cent after the electric drive was introduced.

8. Convenience for Detached Buildings.—The electrical method enables power to be supplied easily and economically to detached buildings or sections, which is not possible with belt or steam transmission; therefore, the buildings, like the machinery within them, can be located for general convenience, and not with special regard to supplying them with power. This subdivision of a plant or manufacturing establishment into a series of detached buildings is an almost absolute safeguard against total destruction by fire; and is thus a practical guarantee of continuous earning powers. If, however, electric power were not employed,

it would be necessary to have long belting systems, involving great losses, and extra heavy wall construction, or a series of small power plants calling for a larger force of men; and considerably less economical in operation than one central power house.

9. Freedom for Growth.—For similar reasons, with electric drive it is a simple matter to extend a building, or add another in any direction, whereas with belting, the shafting must be installed originally large enough to allow for extension; or else it must be replaced later; in which case the operation of the existing line shafts would be interfered with.

10. Shutdowns Less Frequent and Less Serious.—An accident in an electrically driven plant usually has a local effect only, simply shutting down one or a few machines, while with belting and shafting the breaking or slipping of a belt, or the failure of a friction clutch, may require the shutting down of a whole plant or a large section thereof. In a large establishment a delay of even a few minutes represents a considerable item in wages, and in addition the interruption of the work is demoralizing. It might be argued that the central station may break down; this is, however, just as likely to happen with one form of power transmission as another.

11. Speed Control.—The variation of speed that is possible with the electric drive, and the convenience as well as the wide ranges of control, are great advantages with most kinds of machine work. The operator can drive the tool to its limit of capacity, and can, on the other hand, instantly relieve it of strain. With mechanical drive the methods of speed control are more limited and require more time to operate than with electric motors. The shifting of the belt on a cone pulley, or the throwing in and out of different sets of gears, takes more effort than the simple turning of a controller handle, which can be placed right

FIG. 13.—GROUP DRIVING OF SMALL MACHINES, SCHENECTADY WORKS, GENERAL ELECTRIC COMPANY.

FIG. 12.—BELT-DRIVEN TOOLS, SHOWING THE COMPLICATION OF OVERHEAD SHAFTING AND BELTS.

at the work, and is thus not so likely to be carried out by the operator to gain slightly in the efficiency or rapidity of his work. The curves given in Fig. 15 show the time required to perform a certain piece of machine work, the speed control being by electrical and mechanical means. The cutting speed in the case of the electric drive being kept absolutely constant and at its maximum value throughout the operation, whereas that of the mechanical drive could not be adjusted as closely as this, but had to vary between control values. The saving in time thus obtained is considerable and correspondingly reduces the shop cost of the article.

12. Increased Output.—Owing to its many advantages, but especially on account of clear head room for crane service and convenient speed control, it is found that the output of manufacturing establishments is in most cases materially increased or the running expenses correspondingly decreased by the introduction of electric motor service.

If a factory or a plant manager contemplates the substitution of electric drive for the ordinary mechanical drive, or other method of power distribution, it would be advisable for him to study carefully the requirements of his work, so as to determine if variable speeds are necessary and what ranges, if individual or group drive would answer, and which type of motor is best suited for each tool or machine to be driven. He should then tabulate the advantages derived and give them their true monetary value; against these he should balance the interest on the additional expenditure, the maintenance and depreciation items. If then the result shows an annual saving which would amount to a sum of five per cent or more of the cost of the new equipment, or the saving of a reasonable amount in the cost of his finished product, it would be a good policy for him to make the change.

OLD AND NEW THEORIES OF LIGHTNING CONDUCTORS.*

By SIR OLIVER LODGE, F.R.S.

KNOWLEDGE of the subject of lightning rods has considerably increased, and the effect of self-induction, which many years ago was completely ignored, has been taken into account and understood. The main differences between what is recommended to-day and

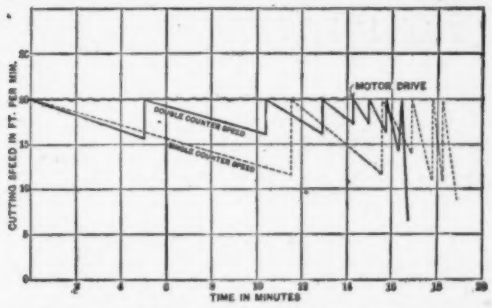

FIG. 15.—CURVES SHOWING LENGTH OF TIME REQUIRED TO PERFORM CERTAIN MACHINE WORK WITH ELECTRIC AND MECHANICAL DRIVE.

what was considered sufficient then depend on the recognition of the influence of self-induction or electrical inertia. Then electricity was treated as if it had no inertia, and as if all that was necessary was to get it from the clouds to the earth as quickly and easily as possible by the shortest path, which may be called the drain-pipe theory. It was supposed that it would

* Journal of the Royal Institute of British Architects.

FIG. 14.—MOTOR-DRIVEN LATHES AT THE WEST LYNN WORKS OF THE GENERAL ELECTRIC COMPANY.

always take the easiest path, and that the easiest path would protect all others. Attention was directed to the quantity of electricity which had to be conveyed down, and to nothing else.

Now, however, it is perceived that it is not so much quantity of electricity that has to be attended to as electrical energy; that this electrical energy is stored between clouds and earth in dangerous amount, and that our object should be to dissipate it not as quickly but as quietly as possible. A sudden dissipation of energy is always violent. No one in his senses wishes to stop a fly wheel or a railway train suddenly; sudden or hasty dissipation is not what is wanted. Gun cotton possesses a store of potential energy locked up in it to a dangerous extent; if it be dissipated suddenly, as by percussion, a violent explosion results; but if it be dissipated gradually, as by a flame, the energy is got rid of without much damage, beyond the liability to fire. An armor plate may be able to stop a cannon ball quickly, but a heap of sand or loose earth does it more safely, because more gradually.

So it is exactly with the store of energy beneath an electrified cloud or between one cloud and another. A lightning conductor of perfect conductivity, if struck, would deal with the energy in far too rapid and sudden a manner, and the result would be equivalent to an explosion. A conductor of moderately high resistance, such as an iron wire, would get rid of it in a slower and therefore much safer and quieter manner, though with too thin a wire there may be risk of fire.

The rush in any case, however, is likely to be rather violent, and, like an avalanche, it will not take the easiest path provided for it, as if it were a trickling stream, but will crash through obstacles and make its own path, some portions of it taking paths which would be quite unexpected. Hence, no one path can be said to protect others, and the only way to protect a building with absolute completeness is to inclose it wholly in metal. An invisible cage or framework of iron wires, however, descending vertically down its salient features, with the utilization of any metal in its construction, suffices for all practical purposes, unless the building is a powder magazine.

The effect of *points*, and of rain also, in gradually dissipating a charge, and thereby contributing to safety, has long been understood; but the feature which has not been known is that there are cases where points are wholly inoperative, viz., when the energy is stored between cloud and cloud, instead of between cloud and earth, and when the initial discharge takes place from one cloud to another; then the lower cloud is liable suddenly to overflow to earth through a region in which there was no previous preparation, and where any number of points, or a rain shower, or any other form of gentle leak, would have been quite inoperative. Then can a violent discharge occur to even the sharpest point; and a hot column of air, such as rises up a chimney, is even preferred to a conductor. These are the flashes against which points and rain are no protection, and these are probably those which do the most damage to protected buildings. But it must be understood that when a flash does occur through a building, it matters little which kind of flash it is—both can be equally sudden and violent; but if the building is well provided with points, the first or prepared kind is not likely to occur, save in exceptional cases; the dangerous liability is then the sudden or overflow variety of flash.

These, then, are the two points of novelty:

1. The possible occurrence of a totally unprepared-for and sudden flash in previously unstrained air, by reason of overflow from a discharge initiated elsewhere, what is called the *B* spark, occurring as the secondary result of an *A* spark.

2. The effect of electrical inertia or momentum, so that the discharge is not a simple leak or flow in one direction, but a violent oscillation and splash or impulsive rush, much more like an explosion, and occurring in all directions at once, without much regard to the path which had been provided for it; no more regard, in fact, than is required to enable the greater part of it to take the good conductors, and to prevent any part of it from being able to enter a perfectly inclosed metallic building.

Even a small lateral fraction of a flash is able, however, to ignite gas if there is a leak, or even to *make* a leak at a "compo" pipe where it is crossed by a bell wire, and then ignite it; hence, after a building has been struck, careful watch should be kept for some time against the danger of fire.

The amount of protection to be allotted to any building is no doubt analogous to the question of insurance generally; that is to say, the amount of premium it is desired to pay may be compared with the capital at stake and the risk run; and this is doubtless a matter for individuals and public bodies to consider for themselves. What the committee can do is to make a study of cases of damage occurring to buildings which on the old lines were supposed to be protected, to tabulate them, and to ask for carefully recorded observations; they can also draw up such hints and suggestions as may be of use to architects whose clients desire their buildings to be protected in a more thorough, but not necessarily a more expensive manner.

These objects, and these attempts at being useful, explain the existence of the present report.

The United States Geological Survey has been conducting a series of tests at St. Louis to ascertain how the different grades of bituminous coal are suited for producer work; and also how the results compared to what was obtained when firing these coals under steam boilers. Among other things the interesting fact was developed that the fuel consumption of the steam plant increased comparatively much more rapidly with the poorer grades of coal. In Germany, there are three or four types of producers in operation which have been working successfully on such material as city refuse, culm banks, etc., containing often not over 20 per cent of combustible matter, and yet doing continuous service in connection with gas engines. If, therefore, gas producer power plants using the higher grades of coal, such as anthracite and coke, have been able to compete with steam plants using inferior grades of bituminous coal, the situation is now completely changed in favor of the first claimant, since we have succeeded in making gas from such fuels as hitherto escaped utilization entirely.

THE CHANNEL TUNNEL.

Now that the question of a tunnel under the English Channel is much talked of, it may be of interest to consider the different projects which have been set on foot, as well as the plans and the preliminary work, surveys, etc., which are actually made up to the present date. The first time we hear of the matter was when the engineer Mathieu laid before Bonaparte a project for passing under the Channel by a tunnel which should be constantly lighted and was to be used as a post route. No more was heard of the matter, however, until 1856, when Thomé de Gamond presented to Napoleon III. a well worked out project for a railroad under the Channel. It was talked of for a short time, between two campaigns, but was then dropped. Afterward, in 1869, the matter was taken up in England by Sir John Hawkshaw and engineer Brunlees, but as the Franco-German war soon followed it prevented any further advance in the question. In 1875 the project came again upon the tapis and this time it began to take a practical shape. On the first of February there was founded under the direction of the economist Michel Chevalier a company which proposed to make the needed researches and plans for the tunnel, and it was capitalized at $400,000, divided into 400 parts. The shares were taken half by the North Railroad Company and one-quarter by Rothschild Brothers. This company commenced work without delay and began negotiations with the authorities. On the second of August, 1875, a bill was passed which declared the projected railroad to be of public utility, and it was to meet a second railway section starting from the English side in the same tunnel. The bill approved the treaty passed between the Minister of Public Works and the Tunnel Company, giving the latter the concession for the railway route to be built.

As to the Tunnel Company, it asked no subsidy from the government and pledged itself to carry out the preparatory and observation work of all kinds such as shafts, soundings, galleries, up to the extent of its capital at least, and this would allow them to form an estimate of the conditions of carrying on the work. It was also to act in co-operation with an English company which would begin building on the other end. But at the moment when all the difficulties seemed to have been surmounted and that the work would enter upon a period of practical realization, the opposition which the project met with on the British side threw it back indefinitely. Nevertheless, since 1872 a company was formed there which had the same aim as the French company, and it was known as the Channel Tunnel Company. During 1875 it obtained from Parliament a bill which gave it about the same privileges which the other company had secured in France. But this concession was allowed to expire, and nothing more was heard of it. This left a free field for the Southeastern Railway Company when it desired to enter into conjunction with the French company in 1880. Parliament was again requested to pass a bill in its favor and there seemed some hope of a conclusion. Then all at once a single objection made by Lord Wolseley overthrew the matter. He declared categorically that in his opinion there was the gravest danger for the United Kingdom from such a tunnel, as it placed it at all times under the risk of an invasion from the Continent, and so great was the prestige of the Marshal that his word was taken as law. Thus the work began by the Southeastern Railway Company was suddenly stopped, and there was so much fear that it would be carried on secretly that a guardian, surveyor's chain in hand, was appointed to see that the galleries did not advance. But on the French side all hope was not lost, and it was expected that the English opinion would change. As will be further seen, the French Tunnel Company took great care to preserve its concession by realizing all the conditions of the contract.

Different ideas were brought out as to how the crossing was to be effected. M. Bunau-Varilla, a prominent engineer, had the following scheme, using a bridge construction at either end, so as to overcome the above objection to the tunnel, as the bridge could be easily cut in time of war. Starting from Dover and ending near Calais at Sangatte, the combination plan started with a five-span bridge running into the sea for about a mile joining on to the tunnel at this point. On the other side the tunnel would end in a bridge in the same way. To pass from the bridge to the tunnel, which lies 62.5 meters lower between rail-levels, two solutions were proposed. First, a mammoth elevator, working in a masonry shaft would take the trains down to the mouth of the tunnel which had four parallel tracks and would lift the trains at the other end. Second, a set of dikes would protect an incline carrying the tracks down an 11 per cent grade and it would join with the proper masonry construction at the tunnel mouth. This arrangement of a bridge would reassure the most timid, as at the first alarm a few shot or mines would destroy one or two of the bridge spans.

The construction of the tunnel itself can be easily carried out, seeing that it would go through what is known as "Rouen chalk," which is of a soft nature, but is impervious to water. The chalk forms the bed of the Channel down to some depth, and this feature is an encouraging one. Besides, in these more recent times there is a friendly relation between the two countries which is favorable to a solution. Last year, in fact, the British Chamber of Commerce desired that the project be brought up and the plans made. Other deliberations show that the subject is increasing in interest on the English side. More recently, when the members of the London County Council made a visit to the Municipal Council of Paris last year, they had occasion to examine the fine relief model of the work which was executed by the French Tunnel Company and heard a conference on the subject made by engineer Albert Sartiaux, of the North Railroad Company. Since then has come up the more recent discussion of the matter in England, which will be remembered, and the presentation of the question before Parliament.

Should the tunnel be constructed, it will no doubt be a simple tunnel without a bridge at the ends. M. Sartiaux, who is authority on the subject, gives some data about the proposed work. What is not generally known is that the work on the tunnel is already commenced, both on the French and on the English side. As to the French company, it did not wish to lose its concession, and so expended the whole of the $400,000 in preparatory work such as shafts, galleries, experimental borings in the rock and trial gallery. Under the direction of a distinguished engineer, M. Ludovic Breton, shafts have been sunk and a preliminary gallery has been dug at Sangatte, near Calais, at 55.20 meters below sea level. On the 18th of March, 1883, this gallery reached a length of 1,839.63 meters, of which 156.10 meters was excavated by hand and the rest by the drill devised by Col. Beaumont. This drill which is specially designed for working in the chalk, worked during eight months and seventeen days upon the 1,683.59 meters of tunnel, with a speed which constantly increased and which reached in the last stages about 400 meters per month. The company continues to pay the French government the expenses for surveillance which the contract calls for, and it gives great attention to keeping the plant and machines at Sangatte in good order. At any time the definite tunnel work could be taken up. As regards the French company's project, which is well considered, it stipulates two tunnels of cylindrical profile having 5.50 meters diameter each and spaced 15 meters apart. The tubes are connected at intervals by cross galleries. The total length of railroad track (one track per tube) would be from 50 to 60 kilometers, or about three times the length of the Simplon, and the maximum depth below sea level is about 100 meters. In a work of this kind the problem of the evacuation of the infiltration water which leaks into the tunnel needs to be well considered by the engineers. As in the mountain tunnels they could adopt a profile which is higher in the middle, so as to drain off the water directly by the tubes. This solution has a capital disadvantage. As the tunnel has the culminating point in the middle and the low points at the banks, in order to mount from the low points to the shore they would need, even with very heavy grades, a considerable lengthening of the slope. An arrangement devised by engineer Ludovic Breton after a careful observation of the subject, dispenses with the slope of the main tunnel. It consists in placing beside the tunnels and somewhat lower down, a preliminary gallery of smaller size which serves in the first place as a construction gallery, and then when the main tunnels are finished it is used as a drainage gallery for the water. It would bring the water to wells upon the shore, whence it would be pumped out. Using such a gallery the tunnels would be attacked at the same time upon seven sections which would be connected together to make the complete tunnel. Not more than 6½ or 7 years is the time estimated for the work. M. Sartiaux considers that the geological conditions as seen from the soundings in the Channel are excellent, and there seems to be a stratum all along the Channel which is thick, durable, and impermeable, and it is very easy to build the tunnel in the chalk without having the disagreeable experience of the Simplon Tunnel. The expense would probably be $50,000,000. To calm all fear of an invasion, the company has planned an ingenious method. At each shore there is a viaduct in the arc of a circle turning about the cliff of Cape Blanc Nez in France and Shakespeare's Cliff in England which the trains must pass in order to descend the slope into the tunnel. In two hours one or the other of these viaducts could be demolished, so that no invasion could be possible.

The utility of the tunnel needs no demonstration. We are surprised when we think that the relations between France and England are represented, in last analysis, by a movement of 1,200,000 passengers per annum by all routes, while between France and Belgium the traffic is 3,500,000 passengers. In the United Kingdom there are 42,000,000 inhabitants, and it is calculated that an Englishman makes on an average thirty voyages yearly. But too many of them remain in their own country, and no doubt a great number would cross the Channel without fear of sea-sickness, when from London to Paris it would be but a five hours trip.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from L'Illustration.

THE DISTILLATION AND RECTIFICATION OF ALCOHOL.*

A. GENERAL CONSIDERATIONS.

THE strongest mash, after fermentation, contains but 12 to 14 per cent of alcohol by volume, and weak mashes contain 8 or 10 per cent only, while commercial spirit must have a strength of at least 80 per cent of alcohol by weight.

The separation of the alcohol from the other products of fermentation is effected by distillation, which consists in boiling the wort and condensing the vapor thus produced. In this way the alcohol can be separated out very easily and completely from the non-volatile substances of the mash—unfermented sugar, grains, husks, salts, yeast, and many by-products of fermentation. But the spirit obtained by simple distillation is still too weak in alcohol, and it is also contaminated with numerous products of subsidiary fermentation—fusel oil, compound esters, aldehyde, etc. which must be removed if a spirit fit for use as a beverage or in the arts is desired.

B. THE THEORY OF DISTILLATION, DEPHLEGMATION AND RECTIFICATION.

1. Ebullition of Mixed Liquids. Simple Distillation.

A distinction must be made between the ebullition of liquids which are physically miscible in all proportions, and that of liquids not so miscible. Alcohol and water, the separation of which is the chief object of distillation, mix with each other in all proportions. The mash also contains fusel oil which does not mix freely with water or weak spirit, but the quantity of fusel oil is so small that we need not discuss the theory of its ebullition, especially as complete experimental data are not to be had.

For mixtures of perfectly miscible liquids the following laws hold:

1. The boiling point varies with the percentage composition of the mixture. If the latter changes during distillation, the change is always such as to raise the boiling point until either a permanent unalterable mixture or one of the ingredients in a state of purity is obtained.

2. The composition of the mixed vapor is dependent upon that of the liquid mixture. If these are the same, the boiling point remains constant. If they are different that ingredient is always more abundant in the vapor than in the liquid, the subtraction of which from the liquid raises the boiling point.

3. The boiling point is higher than the temperature at which the sum of the maximum or saturation tensions of the two separate vapors is equal to the external pressure.

From these laws it appears that when a mixture of alcohol and water is boiled, the alcoholic strength of the vapor exceeds that of the liquid which consequently becomes weaker, but still continues to evolve vapor stronger than itself. As the liquid becomes weaker in alcohol, its boiling point rises until, finally, the last remnant of the alcohol goes over before all the water has been converted into steam. If all the vapor that has passed over is now condensed, a distillate is obtained which is much stronger in alcohol than the original liquid, and if this distillate is redistilled, a still stronger product is obtained. By repeating the operation several times a very strong spirit can be extracted from a very weak alcoholic mixture.

GROENING'S ALCOHOL TABLE.

Strength of Liquid, Volume Per cent.	Boiling Point, Deg. C.	Boiling Point, Deg. F.	Strength of Vapor, Volume Per cent.	Strength of Liquid, Volume Per cent.	Boiling Point, Deg. C.	Boiling Point, Deg. F.	Strength of Vapor, Volume Per cent.
90	78.75	173.8	92.0	15	90.00	194.0	66
80	79.38	174.9	90.5	12	91.25	196.2	61
70	80.00	176.0	89.0	10	92.50	198.5	55
60	81.25	178.2	87.0	7	93.75	200.8	50
50	82.50	180.5	85.0	5	95.00	203.0	42
40	83.75	182.8	82.0	3	96.25	205.2	36
30	85.00	185.0	78.0	2	97.50	207.5	28
20	87.50	189.5	71.0	1	98.75	209.8	13
18	88.75	191.8	68.0	0	100.00	212.0	0

The above table shows the alcoholic strength of the vapor evolved by a liquid mixture of given alcoholic strength and the corresponding boiling point. Doenitz has extended this table and included percentages by weight.

From this table can be computed the proportion of a mixture of alcohol and water which must be distilled off to obtain all the alcohol in the distillate, and the alcoholic strength of that distillate.

If a is the weight and m the strength (percentage of alcohol by weight) of the original mixture, d the weight and c the strength of the distillate, r the weight and n the strength of the undistilled residue we have, as there is no loss either of alcohol or of water, $a = d + r$, and $am = dc + rn$. Hence

$$d = a\frac{m-n}{c-n} \text{ and } r = a\frac{c-m}{c-n}.$$

If we stop the operation before much change has been effected in the composition of the liquid, we may take c equal to the strength of vapor which corresponds to the mean strength of the liquid as given in the table.

For example, if a mixture containing 90 volume per cent, or 85.8 weight per cent of alcohol, is boiled down to 88 volume per cent, or 83.2 weight per cent, the strength of the distillate may be taken as 92.3 per cent by weight (88.8 by volume), corresponding to the mean strength of the liquid, 89.0 by volume, or 84.5 by weight. Hence $c = 88.8$, $m = 85.8$, and $n = 83.2$, and if the original weight, a, is 1,000 pounds, we have:

$$d = 1{,}000 \times \frac{85.8-83.2}{88.8-83.2} = 464 \text{ and}$$

$$r = 1{,}000 \times \frac{88.8-85.8}{88.8-83.2} = 536$$

Hence the weight of the distillate is 464 pounds, and the weight of absolute alcohol which it contains is 88.8 per cent of this, or 412 pounds.

In this way the following table has been computed, which solves all such problems more directly.

Example 1.—One pound of a mixture containing 50 per cent by volume of alcohol is distilled until the residue contains 10 per cent by volume. What are the amount and strength of the distillate?

According to the table 45.2 pounds of a mixture of 50 volume per cent, or 42.5 weight per cent, are reduced to 20.7 pounds when distilled down to a strength of 10 volume per cent, or 8.1 weight per cent. Hence 1 pound is reduced to $\frac{20.7}{45.2} = 0.458$ pound, yielding $1 - 0.458 = 0.542$ pound of a distillate which contains $\frac{1 \times 42.5 - 0.458 \times 8.1}{0.542} = 71.5$ per cent by weight, corresponding to 78.2 per cent by volume, of alcohol.

Example 2.—What proportion of a mash containing 14 per cent by volume, or 11.3 per cent by weight, of alcohol, must be distilled over in order to obtain all of its alcohol and what is the strength of the distillate? 22.3 pounds of liquid of the above strength leave a residue of 14.5 pounds when all the alcohol has been distilled off, that is, when the strength of the residue is 0. Hence 1,000 pounds of such mash would yield $1{,}000 \times \frac{14.5}{22.3} = 650.2$ pounds of residue free from alcohol and 349.8 pounds of distillate containing $\frac{1{,}000 \times 11.3}{349.8} =$ 32.3 per cent by weight of alcohol.

Example 3.—If the distillate of the last example is re-distilled until all of its alcohol has just passed over and if this process is repeated several times, the strength of each distillate may be found in the same manner from the strength of the preceding distillate. The results are as follows:

Original mash contains 11.3 per cent by weight of alcohol.

First distillate contains 32.3 per cent by weight of alcohol.

Second distillate contains 55.0 per cent by weight of alcohol.

Third distillate contains 70.3 per cent by weight of alcohol.

Fourth distillate contains 78.5 per cent by weight of alcohol.

Fifth distillate contains 83.0 per cent by weight of alcohol.

According to Sorel's observations, Groening's figures do not quite agree with the results of practical experience, being somewhat too high, especially for mixtures weak in alcohol, owing to condensation of still weaker liquid on the walls of the still, which necessarily increases the strength of the vapor or distillate. By immersing the still in a glycerine bath and thus keeping its temperature equal to that of the vapor within it, Sorel obtained the correct figures, which are given in the following table. (Comptes Rendus, March 27, 1893.)

Strength of Liquid, Volume Per cent.	Strength of Vapor According to Groening, Vol. Per cent.	Strength of Vapor According to Sorel, Vol. Per cent.	Difference, Vol. Per cent.
0	0	0	0
5	43.4	35.75	7.65
10	57.2	51.00	6.20
15	65.4	61.50	3.90
20	71.3	66.20	5.10
25	75.1	67.95	7.15
30	78.1	69.26	8.84
35	80.5	70.60	9.90
40	82.3	71.95	10.35
45	83.8	73.45	10.35
50	85.1	74.95	10.15
55	86.2	76.54	9.66
60	87.3	78.17	9.13
65	88.2	79.92	8.28
70	89.0	81.85	7.15
75	89.8	84.10	5.70
80	90.6	86.49	4.11
85	91.5	89.05	2.45
90	92.6	91.80	0.80
95	95.4	95.05	0.35
97.6	97.6	97.60	0.00

DOENITZ'S ALCOHOL TABLE.

A	B	C	D	E	F
Boiling Point, Deg. C.	Boiling Point, Deg. F.	Strength of Liquid, Volume Per cent.	Strength of Liquid, Weight Per cent.	Strength of Vapor, Volume Per cent.	Strength of Vapor, Weight Per cent.
99.0	210.2	1.0	0.8	13.0	10.5
98.2	208.8	2.0	1.6	28.6	23.5
97.4	207.3	3.0	2.4	35.0	29.0
96.6	205.9	4.0	3.2	39.9	33.3
95.9	204.6	5.0	4.0	43.4	36.5
95.2	203.4	6.0	4.8	46.7	39.5
94.5	202.1	7.0	5.6	49.8	42.3
93.9	201.0	8.0	6.4	52.3	44.7
93.3	199.9	9.0	7.2	54 5	46.8
92.6	198.7	10.0	8.0	57.2	49.4
92.1	197.8	11.0	8.9	59.0	51.2
91.5	196.7	12.0	9.7	60.8	53.0
91.1	196.0	13.0	10.5	62.4	54.6
90.6	195.1	14.0	11.3	64.0	56.2
90.2	194.4	15.0	12.2	65.4	57.7
89.7	193.5	16.0	13.0	66.8	59.1
89.3	192.7	17.0	13.8	68.0	60.4
89.0	192.2	18.0	14.6	69.2	61.6
88.6	191.5	19.0	15.4	70.3	62.8
88.3	190.9	20.0	16.3	71.3	63.9
87.9	190.2	21.0	17.1	72.1	64.8
87.7	189.9	22.0	17.9	73.0	65.7
87.4	189.3	23.0	18.8	73.7	66.5
87.1	188.8	24.0	19.6	74.4	67.3
86.9	188.4	25.0	20.5	75.1	68.1
86.6	187.9	26.0	21.3	75.8	68.8
86.4	187.5	27.0	22.1	76.4	69.5
86.2	187.2	28.0	23.0	77.0	70.2
86.0	186.8	29.0	23.8	77.6	70.8
85.7	186.3	30.0	24.7	78.1	71.4
85.5	185.9	31.0	25.6	78.7	72.1
85.3	185.5	32.0	26.4	79.2	72.7
85.1	185.2	33.0	27.3	79.7	73.2
85.0	185.0	34.0	28.1	80.1	73.7
84.8	184.6	35.0	29.0	80.5	74.1
84.7	184.5	36.0	29.9	80.9	74.6
84.5	184.1	37.0	30.7	81.2	75.0
84.4	183.9	38.0	31.6	81.6	75.5
84.2	183.6	39.0	32.5	82.0	75.9
84.1	183.4	40.0	33.4	82.3	76.3
83.9	183.0	41.0	34.3	82.7	76.7
83.8	182.8	42.0	35.2	83.0	77.1
83.7	182.7	43.0	36.1	83.3	77.4
83.5	182.3	44.0	37.0	83.6	77.8
83.4	182.1	45.0	37.9	83.8	78.1
83.3	181.9	46.0	38.8	84.1	78.4
83.1	181.6	47.0	39.7	84.3	78.7
83.0	181.4	48.0	40.7	84.6	79.0
82.9	181.2	49.0	41.6	84.8	79.3
82.8	181.0	50.0	42.5	85.1	79.6
82.7	180.9	51.0	43.5	85.3	79.9
82.6	180.7	52.0	44.4	85.5	80.2
82.5	180.5	53.0	45.4	85.7	80.4
82.4	180.3	54.0	46.3	86.0	80.7
82.3	180.1	55.0	47.3	86.2	81.0
82.1	179.8	56.0	48.3	86.4	81.2
82.0	179.6	57.0	49.2	86.6	81.5
81.9	179.4	58.0	50.2	86.9	81.8
81.8	179.2	59.0	51.2	87.1	82.0
81.7	179.1	60.0	52.2	87.3	82.3
81.6	178.9	61.0	53.2	87.5	82.5
81.5	178.7	62.0	54.2	87.6	82.7
81.4	178.5	63.0	55.2	87.8	83.0
81.3	178.3	64.0	56.2	88.0	83.2
81.2	178.2	65.0	57.3	88.2	83.4
81.2	178.2	66.0	58.3	88.3	83.6
81.1	178.0	67.0	59.3	88.5	83.8
81.0	177.8	68.0	60.4	88.6	84.0
80.9	177.6	69.0	61.4	88.8	84.2
80.8	177.4	70.0	62.5	89.0	84.4
80.7	177.3	71.0	63.6	89.1	84.6
80.6	177.1	72.0	64.6	89.3	84.8
80.5	176.9	73.0	65.7	89.4	85.0
80.5	176.9	74.0	66.8	89.6	85.2
80.4	176.7	75.0	67.9	89.8	85.5
80.3	176.5	76.0	69.0	90.0	85.7
80.2	176.4	77.0	70.2	90.1	85.9
80.1	176.2	78.0	71.3	90.3	86.1
80.0	176.0	79.0	72.5	90.4	86.3
79.9	175.8	80.0	73.6	90.6	86.6
79.8	175.6	81.0	74.8	90.8	86.8
79.7	175.5	82.0	75.9	91.0	87.0
79.7	175.5	83.0	77.1	91.1	87.2
79.6	175.3	84.0	78.3	91.3	87.4
79.5	175.1	85.0	79.5	91.5	87.7
79.4	174.9	86.0	80.7	91.6	87.9
79.3	174.7	87.0	82.0	91.8	88.1
79.2	174.6	88.0	83.2	92.1	88.5
79.2	174.6	89.0	84.5	92.3	88.8
79.1	174.4	90.0	85.8	92.6	89.2
79.1	174.4	1000.0	90.0	85.8	83.5	182.3	39.3	44.0	37.0
79.2	174.6	536.0	88.0	83.2	83.8	182.8	37.6	42.0	35.2
79.4	174.9	355.0	86.0	80.7	84.1	183.4	36.0	40.0	33.4
79.6	175.3	264.0	84.0	78.3	84.4	183.9	34.6	38.0	31.6
79.7	175.5	208.9	82.0	75.9	84.7	184.5	33.3	36.0	29.9
79.9	175.8	172.0	80.0	73.6	85.0	185.0	32.0	34.0	28.1
80.1	176.2	146.0	78.0	71.3	85.3	185.5	30.8	32.0	26.4
80.3	176.5	127.0	76.0	69.1	85.7	186.3	29.7	30.0	24.7
80.5	176.9	111	74.0	66.8	86.2	187.2	28.6	28.0	23.0
80.6	177.1	99.3	72.0	64.6	86.6	187.9	27.6	26.0	21.3
80.8	177.4	89.9	70.0	62.5	87.1	188.8	26.7	24.0	19.6
81.0	177.8	82.0	68.0	60.4	87.7	189.9	24.9	22.0	17.9
81.2	178.2	75.3	66.0	58.3	88.3	190.9	25.7	20.0	16.3
81.3	178.3	69.5	64.0	56.2	89.0	192.2	24.0	18.0	14.6
81.5	178.7	64.7	62.0	54.2	89.7	193.5	23.2	16.0	13.0
81.7	179.1	60.4	60.0	52.2	90.6	195.1	22.3	14.0	11.3
81.9	179.4	56.6	58.0	50.2	91.5	196.7	21.5	12 0	9.7
82.1	179.8	53.3	56.0	48.3	92.6	198.7	20.7	10.0	8.1
82.4	180.3	50.2	54.0	46.3	93.9	201.0	19.9	8.0	6.4
82.6	180.7	47.6	52.0	44.4	95.2	203.4	19.0	6.0	4.8
82.8	181.0	45.2	50.0	42.5	96.6	205.9	18.1	4.0	3.2
83.0	181.4	43.1	48.0	40.7	98.2	208.8	17.1	2.0	1.6
83.3	181.9	41.1	46.0	38.8	100.0	212.0	14.5	0.0	0.0

* Translated from Maercker's "Spiritusfabrikation."

II. Compound Distillation, Rectification and Dephlegmation.

The production of high-proof spirits from fermented mashes by simple distillation is a tedious process, for, as we have seen, five successive distillations are required to obtain a spirit containing 83 per cent of alcohol from a mash which contains 11.3 per cent. As such a process is technically impossible, apparatus for compound distillation, in which high-proof spirit is obtained in a single operation, has long been in use. This result is possible only by effecting repeated condensation and re-vaporization in the same apparatus. The rectification and dephlegmation apparatus of modern distilleries is constructed on a principle which requires a brief explanation.

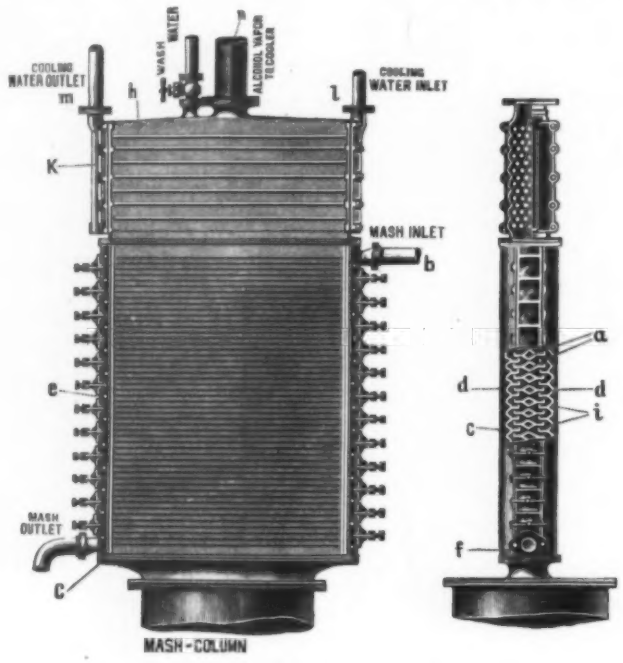

FIG. 1.—THE WAGENER DEPHLEGMATOR.

Rectification and dephlegmation are so intimately related that neither is conceivable without the other. In modern distilling apparatus the alcoholic vapor evolved from the heated mash flows first through a rectifying column and thence to a dephlegmator or concentrator, in which it is cooled, partially condensed and consequently strengthened. The condensed liquid flows back from the dephlegmator to the rectifying column where, as it descends, it meets an ascending stream of weak alcoholic vapor. Contact with the hot vapor re-distills the liquid and thus increases the alcoholic strength of the vapor. The continued repetition of this process produces a very strong spirit.

It appears, then, that the rectifying column and the dephlegmator are mutually dependent, the dephlegmator, so to speak, feeding the rectifier with liquid while the rectifier supplies the dephlegmator with vapor which is to be strengthened by condensation. In some forms of apparatus, however, the rectification takes place in the dephlegmator itself or in a chamber, only 32 inches high, below it. This apparatus dispenses with the tall rectifying column and can therefore be installed in a building of little height.

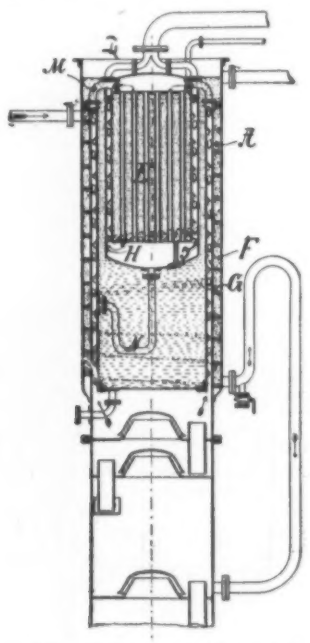

FIG. 2.—THE EWALD DEPHLEGMATOR.

Rectification may be defined as the strengthening of spirit by repeated distillation. The method by which the alternate condensation and evaporation are brought about does not affect this definition.

Two contradictory theories of the action of the dephlegmator have been put forth. In the dephlegmator the vapor coming from the rectifying tower is partially condensed either by cold water or by mash which is thus heated before it goes to the distilling column. It was formerly assumed that in this process the vapor is divided into a portion weak in alcohol, which is condensed and flows back to the rectifying column, and a portion strong in alcohol which passes in a state of vapor to the final or spirit condenser, where it is condensed into high proof spirit.

This view has been vigorously opposed by Pampe, who has very properly objected that a strengthening of alcohol vapors by means of partial condensation has never been proved by experiment and is, furthermore, impossible. According to Pampe the vapor is condensed in the dephlegmator without any change in composition, and is not divided into a stronger and a weaker portion. The action of the dephlegmator, as of all rectifying apparatus, consists in this, that the condensed liquid is again vaporized by the hot vapor streaming after it and that the vapor is strengthened in this process, in exact accordance with Groening's table and precisely as it is strengthened in simple distillation. It must be admitted that Pampe's explanation is perfectly satisfactory, and that there is no necessity of the assumption, for which there is no experimental foundation, that the vapor is divided into a stronger and a weaker portion in the act of condensation in the dephlegmator.

Thus we arrive at the most probable explanation of the strengthening effect of the dephlegmator, namely, that it causes frequently repeated condensation and revaporization, the latter accompanied by increase of alcoholic strength.

The liquid, known as low-wine or singlings, which has been condensed in the dephlegmator and has not been again converted into vapor therein, returns to the rectifying column, and trickles downward through the successive compartments into which that column is divided. Here an ascending current of vapor distilled from the mash meets the liquid in such a manner as to make the best use of the principle of opposed flow, so that the liquid becomes weaker as it descends, and the vapor becomes stronger as it ascends. On entering the top of the rectifying column, the strongly alcoholic liquid first encounters vapor stronger than itself, but not enough stronger to prevent its taking up additional alcohol from the liquid and, consequently, weakening the latter. At each stage in its descent the liquid is weaker than it was at the preceding stage, but as the vapor which it meets is also weaker than the vapor encountered at the preceding stage, the absorption of alcohol by the vapor from the liquid continues until the liquid arrives at the bottom of the tower entirely free from alcohol.

The action of the dephlegmator, also, will be most perfect if in it the cold water or mash flows downward, while the vapor ascends so that the drops of liquid condensed from the vapor come into contact with progressively warmer parts of the refrigerating surface as they trickle downward and, being thus heated, readily give up their alcohol to the opposing current of vapor. With some improved dephlegmators no rectifying column is required, as has already been observed. The place of the rectifying column is supplied by one or two chambers in which the liquid which flows from the dephlegmator is re-heated. These chambers are placed at the top of the first distilling column. Pampe formulates as follows the most important laws concerning the dephlegmators:

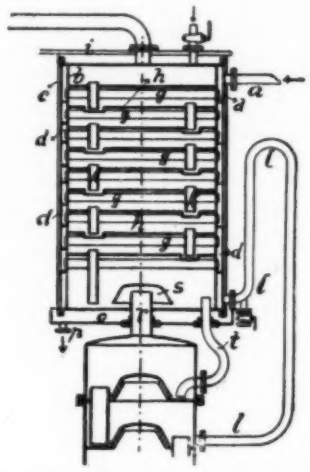

FIG. 3.—THE GESSNER DEPHLEGMATOR.

1. The vapor must flow through the dephlegmator slowly.

2. The cooling must be very gradual, that is, the difference between the temperature of the refrigerating surface and the vapor must not be too great.

3. The vapor and the cold water or other refrigerant must flow as nearly as possible in opposite directions.

4. The condensed liquid must move from a colder to a warmer part, and in a direction opposed to that of the vapor.

In a well-designed dephlegmator, according to Pampe, 11,900 B. T. U. are absorbed by the cooling water for each 264 gallons of mash distilled, the strength of the distillate being 90 per cent by volume of alcohol. Many dephlegmators waste more than twice the above quantity of heat.

A more recent experiment was made in 1901 by officials of the Association of Spirit Manufacturers of Germany with an apparatus of Wagener's construction. Spirit of 90.72 volume per cent of alcohol was produced from 264 gallons of mash. In the dephlegmator 1,478 pounds of water were heated from 132.9 deg. F. to 163.8 deg. F. Consequently, 44,600 B. T. U. were absorbed by the dephlegmator water for 264 gallons of mash. The remainder of the heat which had to be abstracted to secure good dephlegmation was lost by radiation or utilized in heating fresh mash.

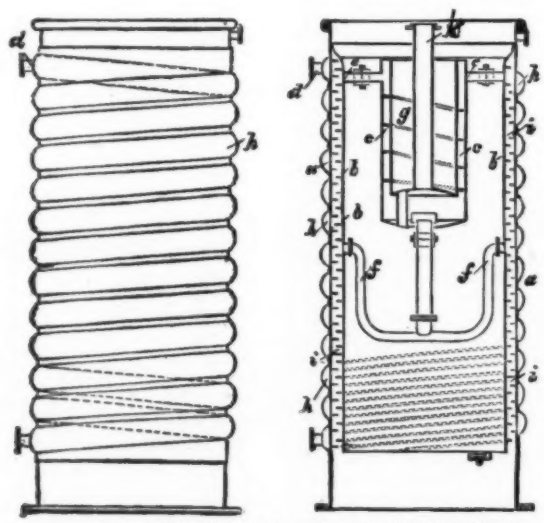

FIG. 4.—THE BOECKENHAGEN DEPHLEGMATOR.

Important improvements have recently been made in the construction of the apparatus commonly known as the dephlegmator or concentrator. Though both names indicate the precipitation of a watery liquid from

the vapor, the modern dephlegmator performs another important function in addition. In the older concentrators this liquid, the phlegma or low-wine, was merely condensed and delivered to the rectifying column where it gave up its alcohol to the vapor which had

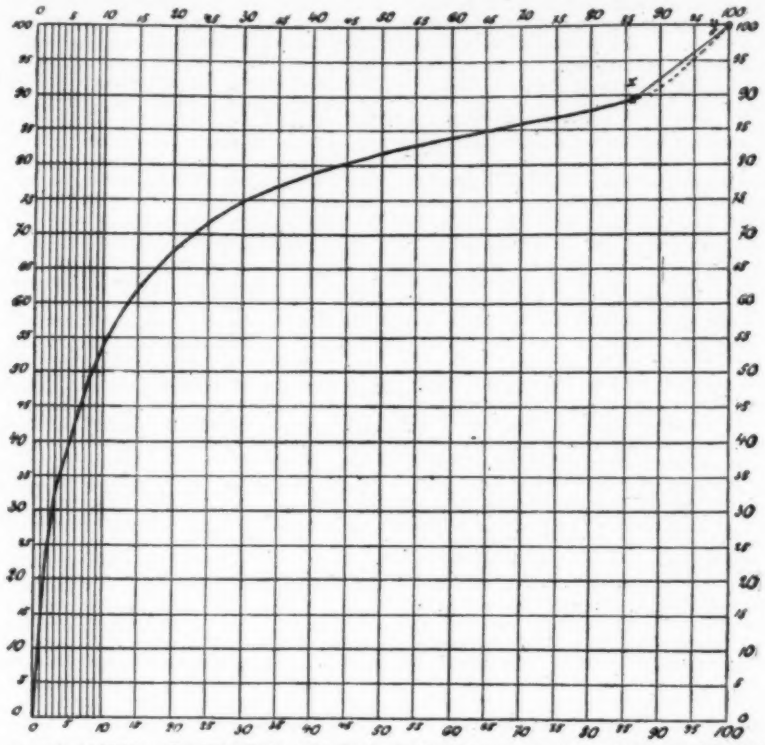

FIG. 5.—ALCOHOL STRENGTHS OF THE LIQUIDS IN PER CENT BY WEIGHT.

come from the distilling column. But in the modern dephlegmator not only is the vapor condensed, but the liquid thus formed is re-vaporized, thus strengthening or rectifying the vapor which it encounters and which, if this rectification is well done, may come directly from the distilling column, the separate rectifying column being suppressed. Consequently the total height of the apparatus and the building can be materially reduced.

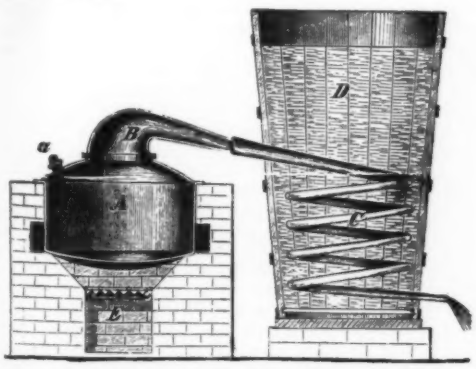

FIG. 6.—SIMPLE DISTILLING APPARATUS.

In the modern dephlegmator, in other words, the vapor distilled from the wort or mash is alternately condensed and redistilled. The vapor gains in alcoholic strength at each repetition of the process, so that the more numerous these alternate condensations and revaporizations are, and the more completely

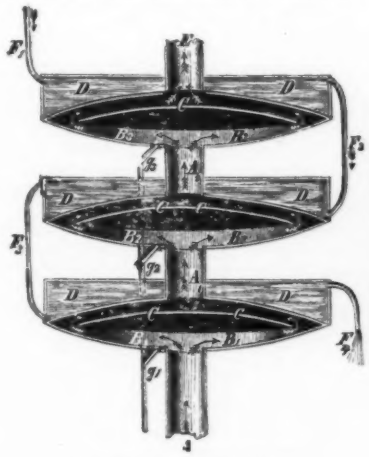

FIG. 7.—PISTORIUS DEPHLEGMATOR BASIN.

every particle of the vapor is subjected to them, the more perfectly will the purpose of the apparatus be accomplished. Hence in all of the best dephlegmators especial care is taken to effect as complete an interchange of heat as possible between the vapor and the refrigerating liquid in order to produce the "phlegma," low wine or condensate, and the latter is caused to assume the form of fine drops which are readily redistilled by the ascending hot vapor. Modern dephlegmators are designed, also, to produce directly from the wort or mash spirit containing at least 85 per cent of alcohol by weight, in order to supply the demand for strong alcohol for light, power, and various technical uses.

Wagener's dephlegmator (Fig. 1) is a rectangular box about 3 feet long, 8 inches wide, and 5 feet high. The mash enters at *b*, descends through a spiral pipe *a* and flows out at *c*, at a temperature of 167 deg. F. to the distilling tower.

The sides of the box are of corrugated iron. On the inside and on the mash pipe are metal strips, to in-

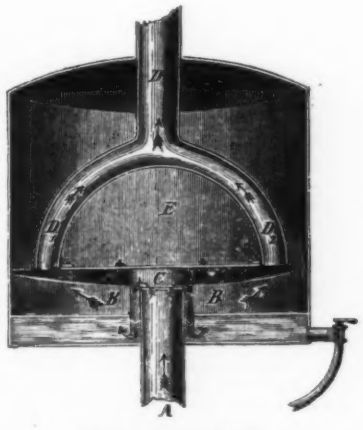

FIG. 8.—PISTORIUS MASH WARMER.

sure intimate contact and exchange of heat with the ascending vapor and the formation of condensed liquid in drops. The upper part of the apparatus, *K*, contains a cold-water pipe. Here the dephlegmation and rectification are completed so thoroughly that vapor containing 86 per cent of alcohol by weight goes to the spirit condenser, while the water is heated to 162 deg. F.

In Ewald's dephlegmator (Fig. 2) the mash first traverses a spiral pipe of 20 turns in the tubular space, *A*, in which the vapor coming from the top of the distilling column is condensed and re-vaporized. Both the inner and outer walls of this space have

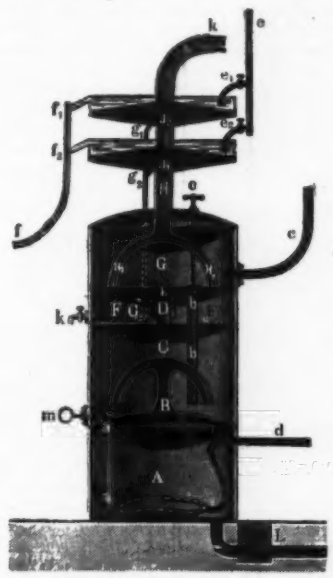

FIG. 10.—PISTORIUS COLUMN DISTILLING APPARATUS.

spiral ridges of corrugated iron to retard the vapor and increase the condensing surface. The mash, heated to 140 deg. F., flows through the bent pipe on the right to the basin at the bottom of the distilling tower below, and the "low wine" or "phlegma" trickles from the tubular space *A* into the two upper basins. The alcoholic vapor flows from *A* through the pipes *M* into the bundle of tubes, *E*, which are surrounded by water. The additional "low wine" condensed in these tubes

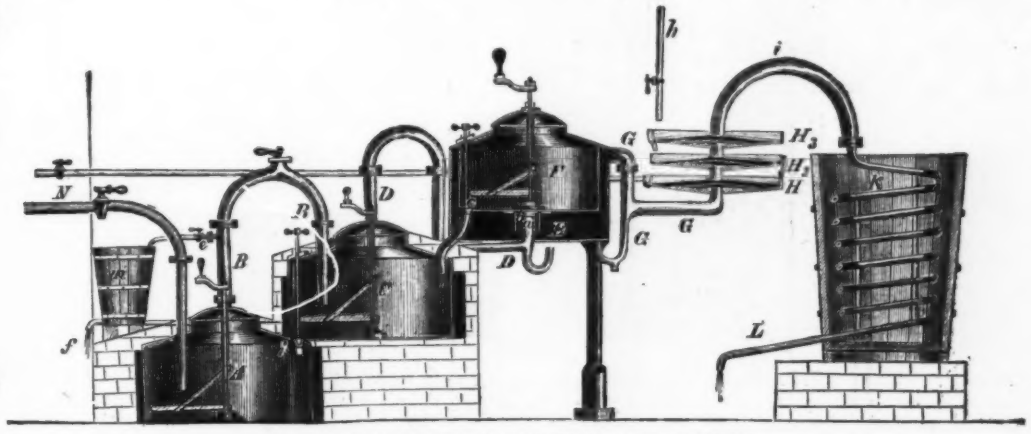

FIG. 9.—PISTORIUS DISTILLING APPARATUS.

flows back through *N* to *A*, and the uncondensed vapor traverses the tubular space which surrounds the tubes *E* and is bathed with water inside and out. This space, like *A*, has spiral ridges on both walls. From it the vapor flows through pipes *L* to the outlet, and the spirit condenser. This apparatus provides a very long path for the vapor and produces strong spirit

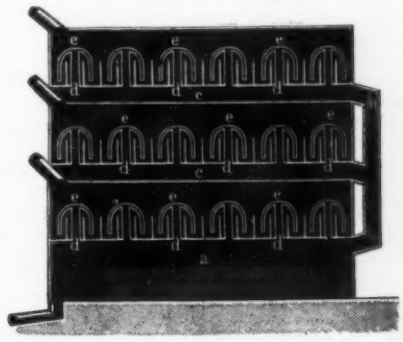

FIG. 11.—PERRIER DISTILLING APPARATUS.

with very little "first running" (fore shots) or "feints" (aldehydes or fusel oil). The water vessel is uncovered. The apparatus is so constructed that it can easily be taken apart for cleaning. Gessner's dephlegmator (Fig. 3) includes a sort of rectifying column. The mash flows through the horizontal tubes *g* to the bent pipe *l*, leading to the distilling column below. The vapor enters at the plug *r* and rises among the mash tubes *g* through the series of perforated plates *h*, bubbling through the condensed liquid (low wine) which covers them to a small height determined by the

overflow pipes which lead from plate to plate. The liquid finally escapes through the bottom overflow *t* to the upper basin of the distilling column. The refrigeration may be increased by allowing water to flow in a thin sheet down the sides of the dephlegmator, inside the outer jacket.

In Boeckenhagen's dephlegmator (Fig. 4) the vapor compartment is tubular and surrounded by a spiral mash pipe of semicircular section, *h*. This vapor space, in turn, surrounds a vessel of water within which is a second vapor space and smaller water vessel. The vapor traverses in succession the outer and inner tubular spaces, of which the former has spiral baffle plates, and finally flows through the outlet *K* to the spirit condenser. The liquid condensed in the inner space flows to the outer through *f*.

III. Heat Consumed in Compound Distillation.

This can be determined if the following data are known:

1. Quantity and initial temperature of mash.
2. Quantity of water used for cooling and its temperature at inlet and outlet.
3. Heat lost by radiation and conduction.
4. Quantity and temperature of spirit produced.
5. Quantity and temperature of spirit mash and of "low wine," if this is discharged separately.

1, 2, and 4 are easily measured, but the determination of 5 is complicated by accession of water from steam and loss by evaporation from the hot wash after discharge. 3, the heat lost by radiation and conduction, can be obtained by difference if all the other quantities are carefully measured. This loss is injurious in the distilling column, but useful in the dephlegmator and spirit condenser where it diminishes the quantity of water required for refrigeration.

For the sharp separation of alcohol and water, in apparatus for continuous operation, repeated distillation in many chambers is unconditionally necessary. The expenditure of heat required to effect such a separation with few distillations is many times greater than is needed with many chambers so that, in most cases, the multiplication of partitions in distilling apparatus

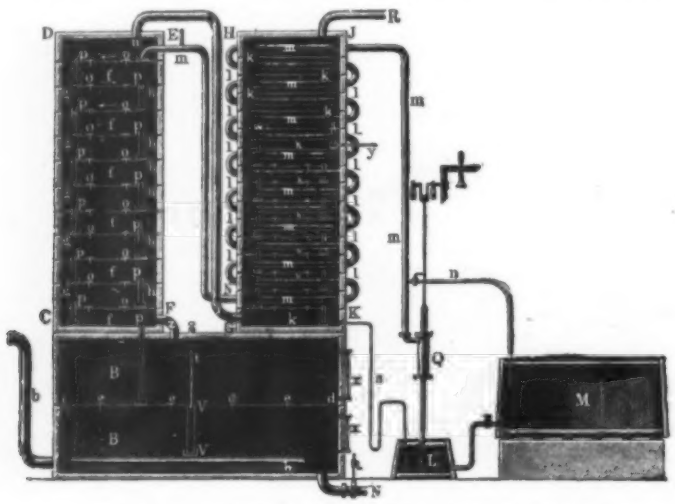

FIG. 12.—COFFEY'S DISTILLING APPARATUS.

results in a saving of expense, and the makers of apparatus who claim that good results can be obtained with few subdivisions are entirely wrong. It is true that the liquid in the lowest compartment soon acquires considerable alcoholic strength, but from this point on progress is slow and many chambers are required for effective working.

This point is well illustrated by Fig. 5 (plotted from Doenitz's alcohol table) in which the abscissas represent strengths of liquid and the ordinates show the strengths of the vapor distilled from that liquid. Above a strength of 70 per cent, the curve rapidly approaches the horizontal. According to Hausbrand the theoretical expenditure of heat also is not least when the contents of the kettle are richest in volatile ingredients. On the contrary, more heat is required to produce 100 pounds of 96 per cent alcohol from an 80 per cent mixture than from one of 50 per cent, which is the most economical strength for rectification.

C. DISTILLING APPARATUS.

Here we shall confine ourselves to a brief description of the most important inventions which have contributed to the perfection of modern distilling apparatus.

1. *Distillation by Direct Firing.*

The employment of the simple pot still (Fig. 6) through twenty-five generations was not due to the intrinsic merits of that device, for its capacity is small and its operating expense heavy, but rather to its cheapness of construction and the plausible objection of distillers that consumers would not like, at least for a considerable time, the altered flavor of the product of improved apparatus. The oldest pot stills had no dephlegmators. The vapor produced in the pot *A* was simply condensed in the worm *C*, which was immersed in water. Argand introduced the principles of dephlegmation, rectification, and preliminary heating by conducting the vapor first upward through a worm immersed in wine and then downward through the condensing worm. In the first worm the vapor underwent dephlegmation and also rectification due to repeated distillation of the opposing stream of condensed liquid which gave off part of its alcohol to the ascending vapor. Thus Argand's invention contained the essential principle of the much later invention of continuous distillation.

Pistorius (1777-1858) devised apparatus for dephlegmation and rectification which may almost serve as a model to-day. Fig. 7 shows his dephlegmator, which has also a certain rectifying effect, though less than that of his rectifier and mash warmer (Fig. 8). In the latter the vapor, after traversing the rectifying capsule *C* and heating the condensed liquid in *B*, passes through the tubes *D* and warms the mash surrounding them in *E*.

In 1817 Pistorius invented his double pot still (Fig. 9), which enabled small liquor distilleries, in countries where concentrated mashes were used, to engage in spirit manufacture on a large scale. It was designed to distill strong and pure spirit cheaply and directly from the mash. Its operation would have been continuous if it had included a continuous feed.

The vapor distilled from the first pot, *A*, which has a stirrer to prevent the direct fire from burning the mash, passes through *B* to the second pot *C* and aids the combustion gases in heating the mash therein. Thence the vapor flows through *D* to the rectifying chamber *E*, which surrounds the mash warmer *F*. In heating the latter, some of the vapor is condensed and the succeeding stream of vapor is compelled to bubble through a layer of the condensate, thus effecting rectification. The tube *B* carries a gage by which the complete exhaustion of the mash is ascertained. From the rectifier and mash warmer *EF* the vapor flows through *G* to the water-cooled dephlegmating basins *HHH* (shown enlarged in Fig. 7). The liquid here condensed flows back through the lower branch of the pipe *G* to the rectifier. The uncondensed vapor passes to the worm *K*. This apparatus was afterward constructed in column form (Fig. 10) and adapted for steam heat. In this form it was very generally employed and is still in use.

Another apparatus with more than one pot was St. Marc's, which was subsequently developed into a semi-continuous apparatus with periodical discharge of the wash. This form is still used for distilling rum in the British colonies.

The St. Marc apparatus, which is adapted to the distillation of wine and thin mashes or worts only, in distinction to concentrated mashes, exhibits the traditional form of all apparatus for continuous distillation with the exception of the apparatus of Ilges and its imitations—namely, the high column divided into closed compartments through which in succession the wort flows downward and the vapor streams upward. Compartments 1 to 8 are filled to the dotted lines with wort, which enters compartment 8 through the pipe *b* and is periodically drawn off to the lower compartments through the tubes *c* which are provided with cocks. The vapor evolved in 1 by the fire below flows through the capsules *d* into 2 and 3, bubbling through and boiling the wort therein, while in compartments 4 to 8 it merely flows through the domes covered by the wort and thus undergoes dephlegmation. As soon as the wort in 1 has been exhausted of alcohol it is discharged, the contents of each of compartments 2 to 8 are let down into the next lower compartment by opening the cocks *c* and the compartment 8 is filled with fresh wort through the tube *b*. In arrangement and operation the apparatus strikingly resembles that of Pistorius, which is ten years older. The Pistorius capsule is simply appropriated and the resemblance of the dome shaped dephlegmators to the Pistorius basins is unmistakable. St. Marc's apparatus was converted from a periodic to a continuous one by simply leaving in the lowest compartment at each discharge sufficient liquid to maintain a stream of vapor. The feed and the discharge of wash remained periodic but the flow of vapor and the discharge of spirit became continuous.

2. *Distillation by Steam.*

The introduction of steam marks an important era in distilling, and contributed greatly to its development. The scorching of thick mashes was avoided and the entire operation gained in certainty, exactness and speed. At first, however, little time was saved, for the steam was not admitted directly into the mash but heated the pot from without. Rumford is usually called the inventor of steam distillation, although Glauber constructed a primitive apparatus for that purpose 150 years earlier.

Steam appears to have been first admitted directly to the mash in an apparatus patented in 1822 by Sir Anthony Perrier. Fig. 11 shows this apparatus arranged for both direct and indirect steam heating. The steam boiler *a* is surmounted by a series of distillation chambers in which the mash is forced by guides to follow a zigzag path. The steam enters the chambers through the pipes *b* and is forced under the mash through the curved tubes *c*. The alcoholic vapor thus evolved from the mash in each chamber flows separately through the tube at the left to the spirit condenser, but the specification of the patent also mentions the possibility of the vapor evolved in each chamber passing to the next "for further elaboration."

The serious application of steam to distillation was made soon afterward, almost simultaneously by Pistorius, Siemens, Coffey, and others. From this period direct steam heating spread rapidly in Germany and England. In France kettles heated by direct fires and combined with distilling towers long held their ground and were finally displaced by the Dubrunfaut system of indirect steam heating.

The constant search for improvement and the desire to obtain a continuous flow of spirit of uniform strength throughout the distillation of a vat of mash led to the construction of apparatus for continuous operation.

If an uninterrupted stream of fermented mash meets an uninterrupted stream of distilled vapor under such conditions of temperature and volume that the mash is continuously resolved into spirit of greater or less strength and wash free from alcohol, the process is called continuous distillation. Among its important advantages are the following: Large kettles are not required, as large quantities of mash can be distilled in small vessels, and the resulting spirit is stronger in alcohol. In the distillation of a potful of mash the vapor is strong only at first and then gradually decreases in strength, but in continuous distillation the strength of the vapor continues to be equal to the maximum strength obtained with the pot still. The same law holds with regard to the final products of periodic and continuous apparatus after they have been strengthened by dephlegmation and rectification. If no water is used for cooling but mash alone is employed in the spirit condenser, as well as in the dephlegmator, the continuous process requires a minimum expenditure of heat, for (neglecting loss by radiation, etc.) the heat consumed is represented by the elevation of the temperatures of the spirit and wash above the initial temperature of the mash, none being wasted on the cooling water. Very naturally the first attempts at continuous distillation were made in France, where wine, a thin and uniform liquid, was the chief source of alcohol. The first French apparatus for continuous distillation was constructed in 1801. Of the many improved forms we shall here mention only the apparatus of Champonnois, which is especially notable for its rectification device. Each chamber of the distilling column contains only a single capsule, a construction followed in the continuous distilling columns for concentrated mashes which were subsequently introduced in Germany. The three upper chambers were devoted to rectification and were supplied with liquid by a dephlegmator immediately above. This dephlegmator was a vertical worm of sheet copper immersed in wine which had already traversed the spirit condenser and then flowed in contact with the wash outlet pipe. Thus the wine received heat from three sources. The column rested on a simple kettle into which wine flowed continuously from the column and from which there escaped a continuous stream of wash which, in consequence of defective boiling, was not always quite free from alcohol.

A very important stage in the development of continuous distillation is marked by Savalle's invention of the steam regulator. This ingenious device first made it possible to admit the steam with the desired uniformity of flow and led to the invention of other regulators.

(To be continued.)

An apparatus of widespread importance to the blind has been invented by Mr. Ernest Vaughan, whereby the blind can correspond freely, either among themselves or with their friends who are not so afflicted. The device comprises as it were a portable printing apparatus. There is a small box about 8 inches in length by 5 inches wide and 2 inches deep divided into two compartments, one comprising a rack containing the type characters with which the printing is to be accomplished, and the other a small empty grating. The type is of special design, having the Braille character at one end and the corresponding Roman letter at the other. At the base of each letter is a small notch, by means of which the blind operator can ascertain the meaning of the particular type handled. This notch fits into grooves provided in the small rack, so that the characters may be stood vertically in position. The blind person recognizes by the touch the particular Braille letters required, and he stands them vertically in the rack to form words, one by one from left to right. When the rack has been thus filled, owing to its working upon a hinge, and by slightly raising it, the sheet of paper can be inserted in position between guides beneath. The rack is then dropped down into position, and by a slight pressure the characters are embossed upon the paper beneath. If a copy of the communication is desired,

a sheet of paper is placed upon the uppermost composition of letters, and by a slight pressure the duplicate or copy is thus procured. The operator can correct his composition line by line, and effect any revisions that may be required. In this instance, the type having the Braille letters uppermost, the resultant printing is in Roman characters, so that the ordinary person can easily read the communication. In corresponding with a blind friend the operator sets the characters with the Braille letters downward. In the case of an ordinary person desiring to write to a blind friend, the characters are set with the Roman letters uppermost, so that they can be seen by the operator. The resultant impression below is of course in Braille, and the recipient can readily read the missive from left to right by the touch.

DMITRI IVANOVITCH MENDELEEF.

THE great Russian chemist, Dmitri Ivanovitch Mendeléef, died in St. Petersburg, February 2, 1907, at the age of 73. Prof. Mendeléef may well be ranked among the foremost chemists and scientists of his time, and it is not too much to say that his name was esteemed and revered throughout the civilized world. He was well known in England, and as long ago as 1882 he was, together with Lothar Meyer, awarded the Davy Medal of the Royal Society, for researches on the periodic classification of elements. To this we shall refer later on. In 1892 he was made a foreign member of the Royal Society—a distinction to which none but the foremost among scientists attain. In 1889 he gave the Faraday Lecture before the Chemical Society of London, and in 1905 was honored by the Royal Society with the Copley Medal. Such is a brief record of the recognition of his abilities shown by that country, and brilliant though it is, it cannot be considered in any way to go beyond what he deserved.

Mendeléef was the youngest of a large family, and was born in February, 1834, at Tobolsk. Here he obtained his primary education, afterward studying natural science at the University of St. Petersburg, taking his degree in 1856. After having taught for some time at Simferopol in the Crimea, and at Odessa, he went at the age of twenty-six to Heidelberg, where he set up in business as an analytical chemist. He was not long there, however, but returned to St. Petersburg in order to become Professor of Chemistry at the Technological Institute. Three years after accepting this post he was offered the Chair of Chemistry at the St. Petersburg University, he being then about thirty years of age.

Perhaps Mendeléef's name will in future be best remembered by reason of his enunciation of what is termed the periodic law of elements. As early as 1869 he made a communication to the Russian Chemical Society. In this he pointed out how that the chemical elements, if arranged in order of their atomic weights, show a periodicity of properties, and form a series of groups which possess more or less distinctive characteristics. This subject he followed up much more systematically and scientifically than had ever been done before. Others had previously noticed that there were a certain number of coincidences of the kind, but there were so many exceptions that it was by no means looked upon in the light of a law, and it remained for Mendeléef to have the courage to surmise that the atomic weights of those substances which did not conform to the "law" had been wrongly ascertained. His surmises were subsequently proved to be correct, and his law established. An additional result to the correction of certain atomic weights was the prediction of undiscovered elements. The existence of three of these he definitely indicated. He found three blanks in his table which manifestly should be filled, and he foretold the existence of three undiscovered elements, to which he gave the provisional names of eka-boron, eka-aluminium, and eka-silicon. Not only this, but he set out in detail the attributes which should belong to these elements. His prophecy, which was made in 1871, was found to be wonderfully accurate. Four years later one of the missing elements was discovered by Lecocq de Bois Baudran, who called it *gallium*. Five years afterward Nilson found another in *scandium*, and in 1886 Clemens Winkler discovered the third, and called it *germanium*. These elements not only fitted correctly into the position assigned to them by Mendeléef, but approximated very closely in their properties to those which he had assigned to them. Still later in history the rare gas elements, argon, helium, neon, krypton, etc., have found correct places in the table.

Taking his process of deduction still further, Mendeléef suggested that what is known as the ether might consist of an absolutely inert gas of an atomic weight very greatly less than that of hydrogen. He could not subscribe to the theory that the ether had no weight, and was imponderable, but he suggested that the majority, at all events, of observed phenomena were compatible with the existence of such a gas as he had indicated, which gas would possess such penetrative power that it could pass with ease through any other substance, and pervade it thoroughly.

The study of the periodic law and the various investigations to which it naturally led, though, as we have said, the work by which he will always be best known, by no means constituted his only sphere of labor. Indeed, his field of investigation and research was particularly wide. He was greatly interested in the researches at low temperatures. He carried out many investigations regarding the behavior of gases under varying pressures and temperatures. He was the author of numerous works on chemical subjects, among these being "Principles of Chemistry," 1870; "Naphtha Production in America and the Caucasus," 1877; and "The Investigation of Solutions from their Specific Gravity," 1887. His attention was by no means entirely confined to theoretical studies; indeed, he was constantly at work suggesting means of utilizing the products of his country and of improving her manufactures. He was also for some time engaged in experimenting with smokeless powders for the Russian government.—Engineer.

ELECTRICAL NOTES.

A German inventor, A. Schwarz, has brought out a type of electric furnace which allows him to obtain exactly the temperature desired. The furnace consists of a tube 6 centimeters in diameter and 80 centimeters long made of sheet iron of moderate thickness. In two points are placed two openings closed by mica and allowing us to observe the phenomena which are produced in the furnace. The whole tube, except the mica windows, is inclosed in sheet asbestos on which is wound a heating coil in nickeline wire 0.75 millimeter diameter. Above this spiral is placed a covering in non-conducting material of 3 centimeters thickness, then an envelope of sheet iron separated from the latter by an air space of 2 centimeters. A set of windows in mica correspond to those of the inner tube. To avoid a loss of heat at the ends of the tube the inventor uses a special arrangement, by placing at the ends two small auxiliary heaters with windings of nickeline wire in which he makes pass a shunt current of a strength which can be regulated. Owing to this disposition he can compensate for the loss of heat at the ends of the furnace, and the heat curves taken by the inventor show that the temperature is quite uniform on the whole length of the furnace.

An important company has been formed at Rome not long since with Italian capital, under the title of "La Marina di Roma," and its main object is to build an electric railroad which will connect Rome with the sea coast, terminating on the Laurentina beach. Some points about the new electric road have been given by Engineer Ventura, who has been concerned in laying out the plans for the line. The electric railroad will begin at the Garibaldi bridge and will follow along the quays of the Tiber. It will pass within the city for over a mile, and will then come out at a point near the Rome-Pisa railroad, on the bank of the Tiber. From this point the line will run westward for the main direction and will have a total length of 25.1 kilometers (16 miles) reaching the ruins of Ostia. It will follow along the Tiber for the whole length of its course up to Ostia, and then will make a turn to the south and run in a straight line until it reaches the Mediterranean at the Laurentina beach. As regards the system of electric traction which is to be used on the line, the alternating single-phase system has been chosen as best answering the requirements of the road. It is proposed to erect a large electric plant at about half way on the length of the railroad so as to supply current for it. An estimate of the cost of the line, including the track and all the rolling stock, is given by the present plans as about $700,000.

A German engineer, Karl Havelik, has made a series of observations as to the best substances to be used for treating telegraph poles. In the cases where ordinary poles deteriorate rapidly, the poles which have been treated with tar-oils last longer, according to experiments, than poles treated with sulphate of copper. On the contrary, in regions where ordinary poles only give way slowly, it seems that the sulphated poles are the most durable. This fact must be attributed to the different action exercised by the atmospheric elements on the copper sulphate and on the tar-oils. In the regions which are favorable to untreated poles, the fact that an injection of copper sulphate is more advantageous is due to the property which the latter has of not being eliminated from the wood nearly as fast as the tar-oils. But in cases where the ordinary poles have only a short life, the copper sulphate is not by any means a good protection. According to him, the phenols which are contained in the tar-oils do not protect the poles in themselves, properly speaking. The favorable effect given by their presence is no doubt due to the fact that the tar-oils escape gradually and in a continuous manner from the treated wood, so that the surfaces of the pole and all the cracks which appear later, are constantly covered with an oily matter and this annuls the bad influence of the passage from a state of dry atmosphere into a damp atmosphere. For this reason the pole generally remains in good condition during all the time in which the tar-oil is being eliminated.

Emile Fortong, a German inventor, has devised a system for the transmission of photographs and other pictures over a wire by a new electric method. In the Fortong system, the two apparatus, transmitter and receiver, are not connected together by an electric circuit, but are independent of the wire. They can be transported to any point in a portable hand case and only need a few cells of battery to work them. The original feature of the device is the fact that the picture is decomposed into a series of characters which can have the form of an ordinary telegram, using figures or letters, and thus it can be sent from any telegraph office. The transformation of an image into an image-telegram is carried out automatically by means of an electric apparatus which decomposes and registers the consecutive elements of the image. To carry this out the photograph which it is wished to transmit is inserted in the apparatus. At the end of twenty minutes or more, the apparatus furnishes a strip of paper carrying perforated notations which express the decomposed image in different shades and in the proper order. Five degrees can be used, for instance, to form a scale of color values or shades, and the perforations are made according to this scale. After securing the perforated strip the latter, which has the perforations in the form of ordinary numbers, can be sent from the nearest telegraph office in the form of a cipher telegram. When the latter is received at its destination the person is enabled to unite the successive numbers, and for this he uses a keyboard somewhat resembling a typewriter keyboard. After striking the keys corresponding to the different numbers, after half an hour he obtains a printed and enlarged reproduction of the image. Inasmuch as the image is decomposed as we have observed, the resulting telegrams can be readily sent over any distance by telegraph apparatus, telephone, radio-telegraphy, etc. It is stated that the persons interested in the Fortong method are taking steps to have it applied in practice.

SCIENCE NOTES.

While physical chemistry, in the first period of its development, was chiefly devoted to the study of the physical properties of matter, the second and present period is characterized by the predominant place of the problem of affinity. This change in the general aspect of chemistry goes hand in hand with a different way of working: in the development of our ideas of matter, physical chemistry introduced physical methods and instruments for the study of physical properties; in the development of our ideas of affinity, physical chemistry has introduced physical principles.

News from Sven Hedin, the Swedish traveler, who last year started from Chinese Turkestan on a journey of exploration in Tibet, reached Calcutta on February 5. Hedin, who when he sent off his courier had already explored 840 miles of unknown country, said he hoped to reach the monastic city of Shigatse, 130 miles from Lhasa, at the end of February. The geographical and geodetic results of the expedition are already exceptionally rich. The explorer lost his whole caravan of animals, but not a single man, and all the maps and collections were saved. Hedin discovered many unknown mountain ranges, rivers, and gold fields, and traveled eighty-four days in the solitude of an Arctic winter, not seeing a single Tibetan.

The potentialities of the gramophone as a colonizing force have been strikingly demonstrated by the recent experience of the governor of the British East African Protectorate. Up till a few months ago the outlying tribes have evinced considerable hostility to white rule, and although they have been somewhat subdued, their demeanor has been one of sullen submission. The governor, however, decided to visit the chiefs of the tribes, and set out upon his hazardous expedition with only a few companions and a gramophone. The talking machine aroused the deepest interest among the unsophisticated natives, who regarded it with almost religious awe and described the instrument as "the great big medicine." In the trans-Tana districts the reproduction of the records aroused the wildest excitement among the 20,000 natives present, and it provoked feelings of good-feeling with the whites. In the wildest part of the Kenia forest the natives could not be persuaded to leave their secluded huts or the depths of the forest to converse with the party, but when the instrument was set in action they quickly left their retreats and gathered around the instrument, prompted by feelings of curiosity to examine its works and fathom the cause of the sound production. At the blast of a bugle call, however, they all fled to their whilom haunts in the most abject terror, and some little persuasion was needed to induce them to again come out. All feelings of hostility were removed by the performances on the gramophone, prolonged concerts with which were given for the entertainment of the primitive people, and on no single occasion, despite the innate hostility that has always hitherto existed against Europeans, was the party molested.

The action of chloride of silicon upon chromium is the subject of a paper read before the Académie des Sciences by E. Vigouroux. In a preceding account he shows the action of this body upon iron, nickel, and cobalt. The present researches relating to chromium were made by the same process and show some new results. Pure chromium is obtained for the purpose by the alumino-thermic reduction of chromium oxide. Some 60 grammes of finely powdered metal are placed in a porcelain trough and inserted in a porcelain tube traversed by a current of chloride of silicon vapor. The attack commences at about a red heat, and as the heat rises we see grayish fumes of chromous chloride come from the trough and deposit mostly on the neck of the receiver. After three hours heat we find in the trough on cooling a rough metallic mass which is to be given a second treatment after overturning it, and after exposing a second time to the gas we find a brilliant metallic substance of quite a different appearance from metallic chromium and weighing not more than 19 grammes. After giving this mass another treatment by the gas at a high heat, about 1,200 deg. C., we find in the trough an agglomerated mass which breaks up easily in the mortar and gives crystalline grains of gray appearance. The author gives the three methods of analysis which he used to find the composition of the substance. He comes very near what would be calculated for the formula Cr_5Si_2 and considers that this is the substance obtained by the action of the gaseous silicon chloride upon metallic chromium at a temperature near 1,200 deg. C. This silicide of chromium Cr_5Si_2 is a new body. It has already been obtained by P. Lebeau and Figueras.

TRADE NOTES AND FORMULÆ.

Fixative.—The following is a reliable preparation:
40 parts by weight of white shellac.
20 parts by weight of sandarac.
940 parts by weight of spirits of wine.

Cement for Rubber Shoes.—Dissolve 25 parts by weight of India rubber and 15 parts of gutta percha in 150 parts of bisulphide of carbon. Solid matter must be disintegrated as much as possible, and it is advisable to put crushed glass into the melting pot to prevent the pieces sticking together, and thereby to accelerate the dissolving process.

This adhesive for fastening leather protectors to rubber tires is to be applied hot: Trioxymethylene, in the form of powder, is added to a solution of Para rubber in benzine or a similar hydrocarbon. The protector is glued to the tire by the mixture in the ordinary manner; then the whole is placed in a drying contrivance and heated until the trioxymethylene decomposes. Formaldehyde vapors will then be evolved from the latter and will act on the adhesive agent, producing immediate coagulation, so that the protector will be firmly and permanently attached to the tire.

Paint for Garden Benches and Arbors.—According to the Werkstatt, a coating for garden benches and arbors can be made by melting purified graphite, India rubber, and shellac over a moderate fire, mixing them with a little sugar of lead, and grinding the mass with linseed or turpentine oil. This compound, it is said, will keep under all conditions of weather and may be recommended for its durability.

A new method of making electrical incandescent bodies from wolfram or molybdenum or alloys of these metals has been patented by the Ujpest Vereinigte Elektrizitäts-Aktiengesellschaft. Compounds of wolfram (tungsten) or molybdenum, such as the oxides, sulphides, and chlorides, reducible to metal by means of hydrogen, when in the form of powder are made into a plastic mass with a binding agent free from carbon (e. g., water). This mass is pressed into the form of the glower and then heated in an atmosphere of hydrogen until the reduction is complete, when the product is ready either for immediate use or after it has been drawn. Another method is to mix the metals in the form of powder with sulphur, and, after adding bisulphide of carbon, to press and anneal them in an atmosphere of hydrogen. The compound of metallic powder and sulphur can also be pressed into the required shape without the employment of bisulphide of carbon, by heating it during the pressing process until the sulphur becomes plastic.

Directions for Making Wood Putty.—There are a great number of wood putties. They serve for filling up the faults or gaps in wood that has been thoroughly dried. Suitable coloring matter should be added to them to make them correspond in color to the wood.

Wood Lime Putty.

Slaked lime powder	1 part
Rye flour	2 parts
Linseed oil varnish	1 part
Umber as required.	

Water is gradually added to the burnt lime until the latter crumbles to a fine powder, when it is mixed with the other ingredients. This putty dries slowly, but in time becomes very hard.

French Wood Putty.

Gum Arabic	1 part
Water	2 parts
Potato-starch	3 to 5 parts

Sawdust Oil Putty.

Very fine sawdust is made into a paste by moistening with linseed oil varnish and long kneading. The mass is very plastic, and may be used as a putty.

Sawdust Glue Putty.

Water	20 parts
Glue	1 part
Fine sawdust as required.	

The glue is first completely dissolved by boiling in water; the sawdust is then poured in a thin stream into the liquid, which is kept in constant motion by stirring.

Wood Gypsum Putty.

This putty is used only for very ordinary woodwork. It is composed of burnt gypsum stirred with glue water. It must be used at once, as it hardens very rapidly.

Wood Putty for Floor-Boards Made of Soft Wood.

(*a*) For floors intended to be washed:

1.	Caseine	500 parts by weight
	Water	4000 parts by weight
	Spirit of sal-ammoniac	500 parts by weight
	Burnt lime	250 parts by weight
2.	Glue	2 parts
	Water	14 parts
	Cement, lime	5 parts
	Sawdust	3 to 4 parts

Both the above must be prepared immediately before use.

(*b*) Putty for floors intended to be varnished:

Glue	2 parts
Water	14 parts
Gypsum	5 parts
Yellow ocher	2 to 4 parts

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